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MONOGRAPHS OF BRITISH EMPIRE VEGETATION

THE VEGETATION OF SOUTH AFRICA

MONOGRAPHS OF BRITISH EMPIRE VEGETATION

THE VEGETATION OF SOUTH AFRICA

BY

R. S. ADAMSON, M.A., D.Sc.

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With 23 figures and 12 maps in the text, and 17 photographs of vegetation

LONDON 1938

BRITISH EMPIRE VEGETATION COMMITTEE

MEMBERS OF THE BRITISH EMPIRE VEGETATION COMMITTEE

(Appointed by the Imperial Botanical Conference, London, 1924.)

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EDITORIAL PREFACE

WHEN the British Empire Vegetation Committee was established by the first Imperial Botanical Conference in 1924 one of the resolutions passed by the Conference [1] instructed the Committee to arrange the publication of a series of Monographs dealing with the vegetation of the Empire.

The long delay in the appearance of the first of these has been due to several causes, one of the chief of which was the lamented death in 1931 of Dr. T. F. Chipp, Acting Secretary of the Committee. This event deprived the Committee of one of the mainsprings of its activity: no one had a better knowledge of the botanists, foresters and agricultural officers of the Empire than Dr. Chipp, whose position as Assistant Director of Kew Gardens and a former Deputy Conservator of Forests in the Gold Coast gave him a key position; and no one could have worked more energetically, unselfishly and genially than he to carry out the schemes which the Committee had undertaken to promote.

The lapse of some years has been necessary before the original scheme could begin to materialise, and after various delays the Committee is now able to publish the first of the Monographs, which deals with the Union of South Africa and has been written by Professor Adamson of Cape Town. Owing to the good sale of *Aims and Methods in the Study of Vegetation*, published by the Committee in 1926, a fund has been accumulated which will cover the cost of production of the present Monograph. Further Monographs, one on South Central Tropical Africa (Northern and Southern Rhodesia, Bechuanaland and Nyasaland), by Dr. J. Burtt Davy, of the Imperial Forestry Institute, Oxford, and one on South-Eastern Australia, by Professor T. G. B. Osborn, lately of the University of Sydney, N.S.W., are in active preparation. Others dealing with the West and with the East African tropical colonies are in contemplation.

[1] See *Imperial Botanical Conference, London*, 1924, *Report of Proceedings*, edited by F. T. Brooks. Cambridge University Press, 1925. Resolution 9, p. 383.

The Committee hopes that everyone interested will support the scheme in every way possible by buying the Monographs and by making their existence widely known. All the Committee's and authors' work is entirely voluntary, and the only funds available for financing it are any profits that can be made.

The general plan of the Monographs will best be gathered from an inspection of Professor Adamson's Table of Contents. The main object is to present what is known of the chief types of natural vegetation in the region dealt with, of the causes of their distribution, and of their exploitation by the inhabitants. It is of special importance that this should be done as soon as possible in view of the increasing rate at which native vegetation is disappearing or being modified out of recognition. A knowledge of what nature produces when she is left to herself is one of the indispensable requisites for wise exploitation.

A. G. TANSLEY.

GRANTCHESTER,

CAMBRIDGE,

February, 1938.

AUTHOR'S PREFACE

WHEN the suggestion was first made that this handbook be written within a specified period of time it was somewhat lightheartedly undertaken. It was only when the details were tackled that the real difficulties of the task became apparent. South Africa is a large country and includes within its boundaries a variety of kinds of vegetation and of climate and other conditions. While in some ways it is a region extremely favourable for the study of the correlations of vegetation with environment, it was early evident that large gaps existed in knowledge of the actual plant covering. Over quite extensive stretches the data available were very scanty, both on the vegetation and on the conditions affecting it, and quite absent on the development. This lack of adequate knowledge has necessitated the account here presented being sometimes in the nature of a preliminary reconnaissance which may provide a working basis which it is hoped will stimulate further study.

An effort has been made to keep the treatment afforded to the different kinds of vegetation uniform throughout, but on account of the great variation in the quantity of information and in the degree to which utilisation has been carried on, this has been difficult and inequalities certainly remain which seem to be at present unavoidable.

The vegetation has been looked upon from the standpoint of the broader features of its structure. No attempt has been made to include local details and, though this will certainly bring forth criticism from those more familiar with any one district, it was inevitable if the account was to be kept at all within the amount of space allowed.

Floristic characters and enumerations of species have been reduced to the minimum: indeed, the only species mentioned are those which definitely characterise certain kinds of vegetation. It is hoped that this method may render the account intelligible to

persons with a minimal knowledge of the South African flora without too much detracting from its value.

The classification of the vegetation is based on the most fully developed parts, even though these are not always the commonest. In the descriptions the use of technical terms is avoided as far as possible. Those that are employed are either defined or otherwise are in general use or are self-explanatory.

The descriptions are based on and only intended to apply to vegetation within the confines of the Union of South Africa. The adjoining territories are only mentioned incidentally. Under each type of vegetation the virgin condition is described and some account given of the changes brought about by human activities. There are also included some notes on the development and on the usage that has been made of each.

The maps that accompany this volume have been drawn specially: they are intended to illustrate general features only and give no details. Some of them are based on published maps in which case the sources from which they were taken is acknowledged. It has not been thought necessary to include a detailed topographical map as such is generally available.

Within the time allowed, it has not been possible to obtain an equal first-hand knowledge of the whole country. Examples of all the types have been seen, but in the descriptions the work of others has been freely drawn upon and used. Individual acknowledgments are not included in the text, but the more important sources of published work dealing with the subject are given at the end. This opportunity is taken to express my indebtedness to the various authors, the more especially as in some cases the conclusions drawn are not identical with those of the original writers.

In addition to published sources of information, I have received assistance from a number of colleagues and others and take this opportunity of expressing my thanks. Professor J. W. Bews, Dr. I. B. Pole Evans, Mr. M. H. Giffen, Dr. J. S. Henkel, Dr. M. R. Levyns, Professor J. F. V. Phillips, Dr. M. A. Pocock and others have given me much information on various parts of the country and assistance in other ways. Dr. J. V. L. Rennie has kindly revised the section on Geology and has given help in many other ways. I have to thank Dr. Pole Evans and Mr. A. W. Bayer for photographs used as illustrations. Further, I desire to thank those

forest officers, farmers and others too numerous to mention individually, who have assisted me with information and in other ways on the course of journeys through the country. In conclusion, I want to thank my wife for continuous help and co-operation in the course of the preparation of this work.

R. S. A.

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THE VEGETATION OF SOUTH AFRICA

CHAPTER I

PHYSIOGRAPHY AND GENERAL DESCRIPTION OF THE UNION

THE Union of South Africa occupies the whole of the southern extremity of the continent of Africa, which is of rather symmetrical form and tapers southwards to a blunt termination. The Union covers an area of more than 472,000 square miles, or more than five times that of Great Britain. It extends from the south coast, of which the southernmost point is at Cape Agulhas in latitude 34° 50′ S., to a point well within the tropics. The most northerly point is on the Limpopo River in latitude 22° 10′ S. The west to east extension is greatest at the northern limits of the country. The extreme points are the mouth of the Orange River in longitude 16° 26′ E. and Oro Point on the frontier between the Union and Portuguese East Africa in longitude 32° 55′ E.

The coastline is smooth and without many indentations or projections, and there are few off-shore islands. Those islands that do occur are close to the coastline and of small size. The coastline for most of its extent is rocky and inhospitable: there is a lack of sheltered bays and harbours.

Boundaries.—The inland boundary of the Union is partly a natural one, partly a quite artificial one which follows a rather irregular course. Starting from the west the boundary is made by the Orange River from its mouth to the line of longitude 20° E.; it then follows this line northwards for a distance of 260 miles to the Nossob River. This river and eastwards the Molopo River, which it joins, make the boundary to a point north of Mafeking; from here it is an arbitrary line that runs north-north-east for about 65 miles and eastwards to the Marico River at Sekwani. The Marico,

and lower the Limpopo River, of which it is a tributary, form the boundary down to the junction with the Pafuri River. From this point the boundary runs south along the crest of the ranges of the Longwe and Lebombo Mountains, crossing the Komati River at its junction with the Crocodile River. It continues south to latitude 25° 50′ S. at the Usubu or Maputo River, and thence runs due east to the coast at Oro Point at the mouth of the Kosi River.

Within the boundaries so traced are two native protectorates, Basutoland and Swaziland, which are not part of the Union but are administered by the Imperial Government. These territories, though politically separate, are here included with the larger country. The Union is separated by its inland boundary from a number of different territories: from west to east these are the Mandated Territory of South-West Africa, the Bechuanaland Protectorate, Southern Rhodesia, and Portuguese East Africa. The last-named is on the east, the others north of the Union. In the present account of the vegetation these adjacent territories are only mentioned incidentally and are not included.

Political Divisions of the Union.—The Union is made up of four provinces which represent the colonies and states at one time separate but since 1910 united as one country. Of these four the Cape Province is much the largest and Natal the smallest. The actual areas of the four are :—

Cape Province	276,739	square miles.
Transvaal	110,450	,,
Orange Free State . . .	49,647	,,
Natal (with Zululand) . . .	35,284	,,
(Basutoland	11,716	,,)
(Swaziland	6,704	,,).

The detailed boundaries of these provinces need not be traced out. In general terms the Cape Province occupies the whole of the south and west of the country; the Orange Free State lies between the Orange and the Vaal Rivers; the Transvaal between the Vaal River and the Limpopo; Natal is bounded on the west by the Drakensberg escarpment.

The western boundaries of the Transvaal and of the Orange Free State are arbitrary lines which do not correspond to the natural

features. The native protectorates, Basutoland and Swaziland, have somewhat artificial boundaries. The former lies to the south-east of the Orange Free State and occupies the area between the Caledon River, a tributary of the Orange River, and the escarpment of the Drakensberg. Swaziland is at the north-east corner of the Transvaal and has arbitrary boundaries. Each of the provinces is divided up into a number of " divisions " for local administration. Certain areas have been set aside as native reserves : examples are Zululand in Natal, and Pondoland, Griqualand East, Tembuland, and the Transkei Territories in the eastern part of the Cape Province.

Physical Features.—The southern extremity of Africa is symmetrical, both in its outline and in its structure. The country consists essentially of an elevated continental plateau with raised margins, and a rather narrow coastal belt of much less elevation. The land area is a very ancient one which gives evidence of comparatively recent elevation. The coastal belt is narrow and deeply cut into by the rivers. The continental shelf has its edge not far removed from the present coastline. The only portions where there are large extents of relatively shallow water are opposite the mouth of the Orange River and south of the extremity of Cape Agulhas. In the last part the so-called Agulhas Bank extends for more than 100 miles from the coastline and covers an area of over 600 square miles.

Tableland and Escarpment.—The elevated interior of the country, which includes far the largest portion, reaches its maximum height at its rim where the land drops in a sharp and distinct escarpment to the coast belt. The structure of the interior may be compared roughly to a saucer with a raised rim. The lowest part, which is about 2,700 feet (820 m.) in height, lies in the basin of the Kalahari, in the southern part of the Bechuanaland Protectorate and northern parts of the Union. From this depression the land rises to the escarpment rim. The rise is not equal all round, it is much greater to the east than to the west. In the north the rise is much less distinct, especially in Bechuanaland, where there is no definite marginal rise. This saucer structure has had the rim broken through at the north-west boundary of the Union by the Orange River.

The escarpment which bounds this large interior tableland is such an important feature that it is advisable to trace the outline. The escarpment forms not only a pronounced natural barrier and divi-

sion, but has been of large importance in determining the movements of the population and the development of the country. The eastern escarpment is made up of the long ridge of the Drakensberg and rises to over 7,000 feet (2,130 m.) in the Transvaal near Lydenburg. The elevation falls in the southern Transvaal, where the Crocodile River and Komati River flow out, but rises again to the maximum in the country further south along the boundary of Natal and Basutoland, where much of the rim rises over 10,000 feet (3,040 m.). The highest point is Mont-aux-Sources, 11,170 feet (3,404 m.). Further south the altitudes become less, falling to about 7,000 feet (2,130 m.) near Maclear, where the escarpment turns westwards. It is continued in a westerly direction as Stormberg, Zuurberg and Sneeuwberg, all of which are over 5,000 feet (1,525 m.) and rise to as much as 8,500 feet (2,590 m.) in isolated summits such as Compassberg. From the western limit of the Sneeuwberg, near Aberdeen, to the eastern extremity of the Nieuwveld range near Beaufort West, the escarpment is lower and less steep. Westwards it rises again in the Nieuwveld Mountains and Kamisberg, which extend to the vicinity of Sutherland and rise to well over 6,000 feet (1,828 m.). From Sutherland the Roggeveld range runs northwards to near Calvinia, forming a rampart of over 5,000 feet (1,525 m.). Beyond Calvinia the escarpment continues through the Hantamsberg along the highlands of Namaqualand to the Orange River.

For the greater part of its length this escarpment forms a very regular and definite step down from the high interior to the lower coastal belt. Elevated ridges or extensions of high land extend out from the escarpment in Zululand and also in the south-eastern Cape, where the ranges of the Tandjesberg, Winterberg and Amatola Mountains form a small extension of the tableland.

The line of the escarpment forms definite mountain chains as viewed from the coast, but in very many parts the land descends gradually on the inland side. To the north the South African tableland is separated from that of Southern Rhodesia by the wide valley of the Limpopo River. The ridge of the Witwatersrand, famous everywhere for its gold, forms the northern limit of the South African tableland proper. This ridge forms the watershed of the Limpopo basin, and also a definite boundary between the smooth country of the " High Veld " on the main plateau and the broken country descending to the Limpopo.

Coastal Belt.—The country between the escarpment and the coastline is not uniform. In the east in Natal there is a rather steep fall in a series of steps from the foot of the escarpment to the coast. The whole strip is narrow and the coastal plain itself is very narrow. North of the Zululand highlands the escarpment is further from the coast. Here the rather low Lebombo Mountains separate a slightly raised part, 1,000–2,000 feet (300–600 m.), from the coastal plain, which is broader than further south and here lies in Portuguese territory.

Along the south the escarpment is further inland and the country on its seaward side is much broken. In the south-east there are offshoots from the escarpment itself. In the south-west the country is traversed by ranges of mountains that owe their origins to foldings of the rocks. These ranges run almost parallel to the coast and enclose on their inland side more elevated country than on the coastal side. For example, in the south-west, just below the escarpment, is a stretch of elevated country 2,000–3,000 feet (600–915 m.) in height, which is bounded on the south by the Swartberg and associated ranges which rise to 6,000–7,000 feet (1,825–2,130 m.) at the highest points: this is the Great Karroo. On the south of the Swartberg, and between that and the coastal ranges, is a smaller and less elevated area known as the Little Karroo. This is 1,000–2,000 feet (300–600 m.) high.

The actual strip on the sea side of the mountains is narrow. The structure along the west coast is similar as far north as the mouth of the Doorn River: beyond that the escarpment itself, here about 3,000 feet (915 m.), forms the first inland elevation. In the subsequent chapters the terms coastal belt and coastal strip are often restricted to the part on the seaward side of the folded mountains and not used in the more general sense of all below the escarpment.

Drainage.—South Africa is a land quite lacking extensive areas of fresh water: the largest lakes are Lake Chrissie in the eastern Transvaal and Lake Fundusi in the northern Zoutpansberg, and neither is large. Other stretches of water are artificial dams or temporary pans or overflows. The large pans are often mapped as lakes, but are quite dry for the greater part of the year.

The drainage system is closely related to the structure. By far the largest and most important river is the Orange, which is over 1,100 miles (1,769 km.) in length. Its principal tributary, the Vaal,

is over 520 miles (836 km.). The Orange rises in the eastern escarpment in the Mont-aux-Sources and flows westwards, entering the sea at the northern boundary of the Union. The Vaal rises in the escarpment mountains in the eastern Transvaal and joins the Orange River near Douglas in Griqualand West. The Orange River and its tributaries drain practically the whole of the great tableland. The crest of the escarpment forms the watershed of the basin in the east, south and west. The Kalahari depression itself drains into the Orange River through the Molopo River and its tributaries, the Nossob and Kuruman Rivers. The valley of the river has been cut down to such an extent that its level now is well below that of this depression.

The Orange River has cut a wide gap in the western escarpment, but the river itself flows in a narrow and steep-sided gorge for 250 miles (400 km.) above its mouth. Near Kakamas, and just below its junction with the extensive but most often dry Hartebeest River, the Orange drops suddenly 450 ft. (137 m.) in the Great Aughrabies Falls. The river above the falls runs in a wide, open valley cut below the general level of the country. Numerous tributaries join the Orange on both banks. In the lower course, below the confluence of the Vaal River, none of the tributaries are permanent, though some of them are of great extent. Some of them only flow on very rare occasions after unusual quantities of rain.

The only other river of importance rising in the interior is the Limpopo, which has its source in the low elevation that forms the eastern fringe of the Kalahari depression. The Limpopo flows north and then east in a wide, open valley and is joined by numerous streams. It finally enters the sea on the east coast north of Delagoa Bay. The Witwatersrand ridge forms the watershed between the basins of the Limpopo and Vaal Rivers. The tributaries of the former have cut back into this watershed so much that the head waters of streams flowing northwards are very near those of others flowing south.

The remaining rivers all have their origins in or close to the escarpment, and are small both in length and in the area of their drainage basins when compared with either the Orange or Limpopo Rivers. In the northern parts some of these streams have cut back beyond the escarpment itself and extended their drainage basins some way into the interior. Most of the rivers flow directly to

the coast. Those rising in the eastern escarpment have steep courses which are often broken by falls of varying height. In their lower courses these rivers run in deep and steep-sided channels. Those rising in the northern part of the escarpment cut through the low range of the Lebombo Mountains in a series of open gorges. In the south-west the main rivers rising in the escarpment and flowing southwards cut through the folded mountains in narrow and often precipitous gorges or "poorts." The largest of these rivers, which enters the sea as the Gouritz River between Mossel Bay and Riversdale, drains most of the western parts of the Great Karroo and the Little Karroo. The river cuts through the Swartberg in an exceedingly narrow and steep-sided gorge, Gamka Poort, and subsequently through the Langeberg in a rather wider gorge. Even quite small tributary streams may run through such narrow gorges traversing the mountains. In contrast to this arrangement, those streams rising in the west-facing escarpment flow northwards parallel to the folded ranges and enter the sea beyond their northern extremity. In the low country near the sea many of the streams, especially those in the south-eastern parts, though running in deep channels, follow a winding or even meandering course.

Natural Vegetation.—The vegetation that exists anywhere is not the result of chance, but is controlled by the conditions of the environment and more especially by the climate. Vegetation is not static, but is always undergoing change. The amount of change may be small and not appreciable without detailed and prolonged examination, or it may be greater and obvious. The causes are varied: the growth of the plants themselves brings about small changes, but more important ones are due to the fact that all vegetation undergoes a process of development. It starts from simple beginnings with few plants, which are largely independent of one another, and gradually passes to conditions with larger numbers and increasing competition and interdependence. The length of time required for this development depends on local conditions. When no disturbance takes place the process will continue up to a phase limited by the local conditions of environment. Such a phase is stable and remains essentially unchanged provided that the conditions are unchanged. Such a stable phase is termed the "climax" of the vegetation. The climax reproduces itself, and, if destroyed, development will again proceed towards it. It is, of course, in com-

paratively rare instances that the whole story can be traced: in most it is only possible to study the later phases of the original development or of regeneration after destruction.

In any region the climax phases exist in a state of equilibrium with the environmental factors, and any alteration in these will result in a change in the vegetation, sometimes small, at others profound. Those parts where, for any reason, the full development has not taken place have a simpler structure with a less complete correlation with the conditions.

The Union is a region in which the activities of man other than on a small scale, have acted on the vegetation for rather short periods of time; as compared with any part of Europe, for very short periods. One result of this is that changes brought about by human interference are usually obvious and readily recognisable: the time of their operation has not been sufficiently long to permit of the establishment of a new state of equilibrium.

In the vegetation the climax need not be the most abundant kind of community, but is the most essential. It is on the structure of the climax communities that a classification is based: in this country the vegetation may thus be divided into five classes. These are:—

1. *Bush*, with the climax made up of shrubs or bushes.
2. *Forest*, with dominant trees, here evergreen trees.
3. *Savanna*, with trees or bushes, usually deciduous, scattered in a grass undergrowth.
4. *Grassland*, without trees or bushes.
5. *Semi-Desert* and *Desert*, where the plant cover is incomplete or lacking.

Each of these classes is divisible into smaller groups, the vegetation types, which are units characteristic of distinct climatic areas. Twelve of these types are recognised, which may be summarised as follows:—

I. Bush. Winter rainfall with dry summer.
   1. Sclerophyll . . . Evergreen bush with small, hard leaves.

II. Forest. Continuous moisture with no dry season.
   2. Temperate Forest . . Small-leaved evergreen forest in cool, frost-free climate.

3. Warm Temperate Forest.	Generally evergreen forest in warmer conditions than 2, with summer rainfall.
4. Sub-tropical Forest .	Evergreen forest with lianes and palms in continuously warm and moist climate.
5. Montane Forest . .	Larger-leaved evergreen forest in cool, wet climate with summer rainfall.

III. SAVANNA. Summer rainfall with dry winter.

6. Temperate Savanna .	Open bush and low grass, with summer rain and moderate temperature.
7. Low Veld . .	Close trees or open forest in warm frost-free climate.
8. Bush Veld . . .	Bush or trees and tall grass in warm climate with cool winters.
9. Bush Savanna . .	Bush or small trees with open warm grass in dry climate, summer and cold winter.

IV. GRASSLAND. Summer rainfall and dry, cold winter.

10. Grassland . . .	Grasses dominant without trees.

V. SEMI-DESERT. Low rainfall.

11. Arid Bush . . .	Open vegetation of low bushes, with cold winters.
12. Succulent Bush . .	Open vegetation with many succulents. Less extremes of temperature than 11.

Animal Life.—South Africa possesses a large and characteristic fauna whose distribution is closely related to that of the vegetation types. At one time the larger animals were a conspicuous part of the life of the country, and even in the arid parts there were herds of characteristic animals. With the spread of settlement these have largely disappeared, or at least have been very much reduced in

numbers. In many parts all that remains to record their one-time occurrence are a few place names. The smaller animals are slowly undergoing the same sort of reduction.

Races.—While archæological evidence shows that South Africa has been inhabited by man for a prolonged period of time, practically the whole of the existing population is of rather recent arrival. The country was discovered by Europeans at the end of the fifteenth century, but the first attempts to settle there did not take place until the second half of the seventeenth century. The Bantu peoples, that comprise the vast majority of the native population, reached the country not very long before the first arrival of Europeans. The exact date of their migration from the north is not certain: Bantu people were certainly in the country at the time of its first discovery by the Portuguese, but their southward migrations continued long after this, and were the causes of clashes with the European settlers in the latter part of the eighteenth century.

When the Bantu people arrived they found a sparsely populated but not uninhabited land: the existing inhabitants were of low culture and presented little obstacle to the advance and occupation of the invaders. The earlier inhabitants were Bushmen and Hottentots, races quite distinct from one another though not distinguished by many of the earlier settlers. Of these the Bushmen were the most primitive, and are usually regarded as the oldest of the races. Bushmen were hunting nomads who, by the seventeenth century, had become largely confined to mountainous country. Though with very primitive culture, the Bushmen have left a memorial of their existence and extent in numerous rock paintings found throughout the country. Very few Bushmen exist at the present time; such as there are are hunters in the remoter districts or are subject to, and largely dependent on, more progressive Bantu tribes.

The Hottentots were cattle-keeping nomads who, at the time of the European settlement, were found in groups scattered over the southern and western parts of the country. At the present time Hottentots of pure race are practically extinct, though mixed people with strongly marked Hottentot characteristics are found in various parts, notably in Namaqualand.

In addition to these various native peoples and the Europeans, there is quite an appreciable population of mixed origin. These

Cape coloured people, who are especially found in the south-west, now form a definite portion of the population. They are Afrikaans speaking and do not use any of the Bantu dialects. They are descended from all the elements of the population, together with Malays, who were brought to the Cape as slaves; more recently some admixture with Indian blood has occurred, as there has been quite an appreciable immigration of Indians, who live principally in Natal, but are found in all the larger centres of population.

Population.—The population of the Union of South Africa consists of less than two million Europeans and about seven and a half million natives and other races. A census of the European population is taken at intervals of five years, and of the whole population at intervals of ten years. The last census was taken in 1936; the previous complete census was in 1921. Owing to financial stringency the census of 1931 was restricted to the European population.

At the 1936 census the figures for the Union and the four provinces were :—

TABLE 1.—*Population*—1936 *Census*

	Total.	Europeans	Bantus.	Asiatics.	Mixed and Others.
Union . .	9,530,649	1,993,734	6,553,622	220,379	762,914
Cape . .	3,522,231	789,293	2,041,179	10,862	680,897
Transvaal .	3,301,016	815,537	2,412,517	26,032	46,930
O.F.S. . .	766,850	199,037	550,714	44	17,055
Natal . .	1,940,552	189,867	1,549,212	183,441	18,032

To show the growth of the population that has taken place the figures for the last four enumerations of the European population are given below :—

TABLE 2.—*Growth of Population*

	Cape.	Transvaal.	O F.S.	Natal.
1921 . .	650,609	543,485	188,556	136,838
1926 . .	706,799	608,622	202,985	158,916
1931 . .	749,231	696,120	205,375	177,449
1936 . .	789,293	815,537	199,037	189,867

There is an excess of males over females in the population: a small one among Europeans but larger in the Bantu population.

Though within the sub-tropical belt, the climate over the greater part of the country is healthy and suitable for Europeans, the

altitude largely modifying the effects of latitude. The northern part of the Transvaal and the lower ground along the more northern part of the east coast are definitely sub-tropical in character and are liable to malaria and other diseases. The aridity of the western parts prevents the development of more than a very sparse population.

Distribution of Population.—The average distribution of population is 14·67 persons per square mile, a figure slightly greater than that for New Zealand but very small as compared with any European country. The distribution is by no means uniform throughout the country, but varies from 1,605 per square mile in Johannesburg, to 0·73 in the Gordonia Division of the north-western Cape Province. Predominantly native areas without towns at all may have quite dense populations, for example, in the Inanda Division of Natal the population is 161 persons to the square mile. The following table gives the average density of population in the four provinces from figures of the 1921 census :—

TABLE 3.—*Persons per Square Mile*

	Total.	European.	Non-European.
Cape. . . .	10·04	2·71	7·69
Transvaal . . .	18·90	6·30	13·98
O.F.S. . . .	12·67	4·14	8·57
Natal . . .	40·51	5·03	36·63

The native population is concentrated along the eastern coast belt, the foothills of the eastern escarpment, and the warmer northern parts of the Transvaal. The central plateau, and especially its western and drier parts, has a sparse native population. A secondary and derived concentration of natives occurs in the towns. Of the European population more than half is in urban areas. According to the last census, 797,573 persons, or 31 per cent. of the total, were in the nine largest towns—Johannesburg, Cape Town, Durban, Pretoria, Port Elizabeth, Germiston, East London, Bloemfontein and Krugersdorp. On the other hand, 87 per cent. of the natives are in rural areas.

The distribution of population depends on the general occupations. Industrial, commercial and mining activities are closely associated and account for the concentration, especially of Euro-

peans, on the Rand and at the ports. The native, except where influenced by civilisation, is dependent on the land and is influenced by the climate and the character of the vegetation in the choice of his habitations. The European farming population is concentrated in much the same parts as the native. But, while the native population has its maximum concentration on the east coast belt, that of the European farmers is on the higher grassland country with a more temperate climate. The coast belt in Natal and the northern parts of the Transvaal, though both supporting large native populations, have climates not altogether favourable to the European owing to the presence of malaria and other factors. In any consideration of the distribution of the population, and especially in that outside the urban and industrial centres, the origin of the peoples must be recognised as a factor. The Bantu peoples migrated into the country from the north and penetrated into and settled in regions where there were familiar types of vegetation which could supply their needs—pasture for animals and timber for construction and firewood. In their southward movement they followed especially the Savanna types of country, though competition might force groups into other types. The Basutos, for example, were driven across the mountains by the more powerful Zulus and took refuge in practically treeless country. On the other hand, the European settler entered the country from the coast, mainly from the south coast, and, passing inland, concentrated in the better watered parts of the grassland, whence a spread took place to other types.

Agriculture.—By far the largest portion of the population is dependent on agriculture for a livelihood. The agricultural activities vary greatly in different parts of the country. In very general terms, livestock and pastoral produce, grain and fruit-growing are the principal activities. Wool, meat, dairy produce, hides, and so forth, are especially associated with the Grassland and Savanna types of vegetation. Sheep-farming, which is the largest single agricultural industry, extends also to the arid regions, where grass is not a characteristic of the vegetation. The native is essentially a pastoralist who keeps animals, but cultivates on a small scale for his own needs.

Mining and Industries.—Mining, and especially gold mining, is the chief source of the country's revenue. The Witwatersrand gold

mines produce 48 per cent. of the world's output of gold. Other important mining products are coal, diamonds, copper, platinum, asbestos, tin and manganese. Iron is worked and a variety of other metals are mined on a small scale. Industries of various kinds have been established in the larger centres of population on the Rand and elsewhere. Most of these are protected by duties on imported goods.

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CHAPTER II

CLIMATE AND WEATHER

THE wide extent of the Union of South Africa has a considerable variety of climate. While most of the country falls in the warm temperate zone, the northern portions reach the tropics. The climate over most of the interior parts is, however, on account of the elevation, more temperate in character than its latitude might suggest.

The whole of the interior and parts of the coast belt receive a high percentage of the possible amount of sunlight. There is also a rather low relative humidity. The clear and dry atmosphere allows large amounts of radiation and large fluctuations of temperature, both daily and seasonal.

The climate in general, and especially that of the coastal belts, is affected by ocean currents. A warm current runs down the east coast and continues round the south coast to the neighbourhood of the Agulhas Bank. An Antarctic current runs up the west coast. This current comes to the surface some distance north of Table Bay and continues north to Angola.

BAROMETRIC PRESSURE

The country lies within the sub-tropical belt of high pressure. The relatively small land surface surrounded on three sides by the ocean modifies the results. The barometric conditions over these oceans are the main factors influencing the pressure distribution in the country. The Atlantic anticyclone in summer is centred off the west coast, while that over the Indian Ocean is near Australia. In summer a low-pressure system, an extension of the equatorial low-pressure belt, extends over the central and east-central parts of the country. On the other hand, in winter the high-pressure system over the Indian Ocean moves eastwards and northwards to a position near the African coast. A secondary high-pressure system forms over the interior, appearing in the early winter and breaking

up about September or October. At this season the south-western corner of the country comes under the influence of a northward extension of the southern low-pressure system.

WIND

While the direction, intensity and moisture-carrying capacity of winds are determined by pressure gradients, they are much influenced locally by topographic and other factors. Over most of the country in summer winds from the high-pressure system over the Indian Ocean blow into the interior low-pressure area. These winds gather moisture over the warm ocean and produce summer rainfall that decreases in quantity from the coast inland. In winter the southern cyclonic extension brings rain-bearing winds to the south-west corner. These winds, blowing from a cold ocean, do not carry large quantities of moisture and do not influence the land beyond the coastal belt.

The actual distribution of wind in selected stations is shown in the accompanying table, in which wind proportions are set out for summer (October to March) and winter (April to September).

TABLE 4.—*Distribution of Wind Directions*

Direction.	Cape Town.		Bloemfontein.		Pretoria		Durban.	
	Summer.	Winter.	Summer	Winter	Summer.	Winter.	Summer	Winter.
N. .	2	24	187	134	98	42	10	35
N.N.E.	2	10	84	34	147	94	59	46
N.E.	—	10	58	155	144	83	255	179
E.N.E.	—	—	2	13	55	42	86	98
E. .	5	10	10	17	49	38	71	37
E.S.E.	2	8	—	17	50	39	24	25
S.E.	10	23	22	64	18	37	48	17
S.S.E.	127	115	6	18	11	35	86	56
S. .	318	224	28	25	14	27	176	147
S.S.W.	99	69	12	14	9	30	100	118
S.W.	20	23	64	77	15	27	6	39
W.S.W.	2	10	22	10	15	32	3	18
W. .	51	13	85	55	26	37	—	28
W.N.W.	138	82	52	39	35	47	3	3
N.W.	119	149	217	207	45	35	6	56
N.N.W.	47	106	108	58	58	40	9	45
Calm	38	113	59	55	212	313	45	68

At the coast inshore winds predominate at all seasons. They may reach gale force occasionally. Intense winds are less frequent inland, though very strong winds, often accompanied by dust-

storms, are of common occurrence in the interior at the beginning of summer. They generally precede thunderstorms. Intense cyclone-like winds occur occasionally; as a rule these follow limited tracks. Hot, dry winds occur on the coast belt: the so-called "Berg winds" blow down from the escarpment and may cause sudden rises of temperature. They do not often continue for long, but may persist for two to three days.

TEMPERATURE

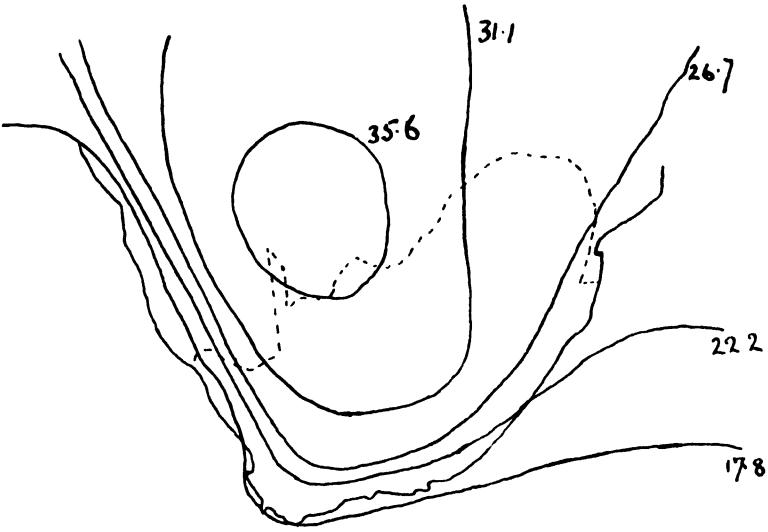
The Union lies sufficiently outside the tropical belt for all parts to have well-differentiated seasons. The temperature distribution is modified greatly by the configuration of the country and by the ocean currents. The interior elevation, which allows intense radiation, produces a condition of very small differences in the mean annual temperatures of different places.

TABLE 5.—*Mean Temperatures and Frosts*

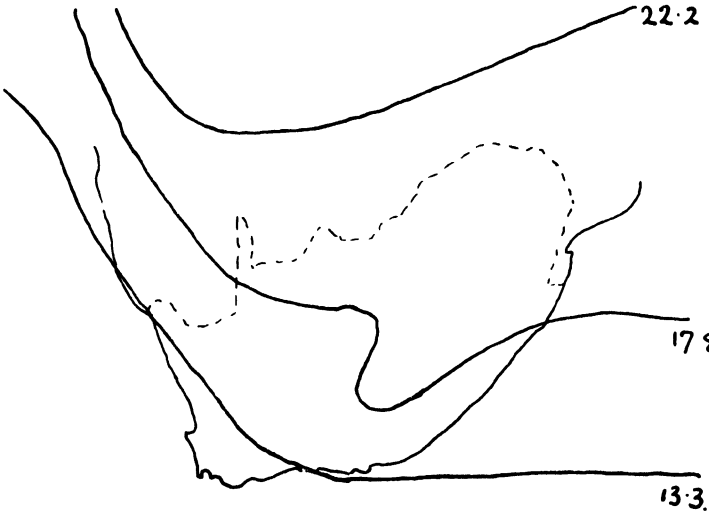
Locality.	Lat. °S.	Long. °E.	Altitude. ft.	m.	Mean Annual Temp. °F.	°C.	Mean Max. Temp. °F.	°C.	Mean Min. Temp. °F.	°C.	Months with Frost.
	° ′	° ′									
Port Nolloth	29 14	16 51	24	7	56·3	13 5	63·5	17 5	49·1	9·4	0
Cape Town	33 54	18 28	40	12	59 9	15 5	71·4	21·8	54·8	12·7	0
George	33 57	22 29	620	189	60 3	15·7	69 1	20 6	51·5	10·8	0
Port Elizabeth	33 58	25 37	176	54	64 1	17·8	70·8	21·5	57·3	14·0	0
East London	33 01	27 54	149	45	64 9	18·3	71·9	22·1	57·9	14·3	0
Port St. Johns	31 38	29 35	153	46	68 3	20 1	74 5	23 6	62·1	16·6	0
Durban	29 50	31 01	30	9	70 0	21 1	76·7	24 8	63·3	17 3	0
Graaff Reinet	32 16	24 32	2,550	777	63·4	17 4	75·5	24·1	51·3	10·7	1
Bloemfontein	29 07	26 12	4,615	1,408	61·5	16·3	74·1	23·3	48·9	9·3	4
Johannesburg	26 11	28 03	5,735	1,746	61·2	16·2	71·9	22·1	50·4	10·2	3
Pretoria	25 45	28 12	4,471	1,363	64 8	18 2	78 0	25·5	51·7	10·9	2
Pietersburg	23 54	29 28	4,270	1,301	64 2	17·8	78·4	25 7	50 0	10·0	3

The summer and winter distributions of temperature are quite different. In summer the hottest part is the Kalahari, and the isothermal lines are arranged around this centre. That for 93° F. (35·6° C.) encloses an oval area with its long axis north and south, just beyond the boundaries. West of this the successive isotherms run almost north and south and parallel to the coast. In the east they are spread out. For corresponding latitudes temperatures are much higher on the east coast than on the west (Map 2).

In winter the isotherms run in a general N.W.–S.E. direction across the country, but also tend to a direction parallel to the west coast (*cf.* Map 3). Some of the results of this distribution are illus-



MAP 2.—Isotherms for January (adapted from Philip's Wall Atlas). Figures in degrees Centigrade.



MAP 3.—Isotherms for July (adapted from Philip's Wall Atlas). Figures in degrees Centigrade.

trated in the table. This gives the seasonal temperature for some of the stations given in Table 5 (p. 18).

TABLE 6.—*Seasonal Temperature*

	Mean Temperature.						Mean Monthly Temperature.					
	Summer.		Winter.		Diff.		Summer.		Winter.		Diff.	
	°F.	°C.	°F.	°C.	°F.	°C.	°F.	°C.	°F.	°C.	°F.	°C.
Port Nolloth	57·2	14·0	55·0	12·7	2·2	1·5	60·3	15·7	52·8	11·6	7·5	4·1
Cape Town .	67·8	19·9	58·3	14·6	9·5	5·3	72·5	22·4	54·1	12·2	18·4	9·8
East London.	68·1	20·0	61·6	16·4	6·5	3·6	70·8	21·5	58·6	14·7	12·2	6·5
Durban .	73·4	23·0	66·6	19·2	6·8	3·8	75·6	24·2	63·1	17·2	12·5	7·0
Graaff Reinet	69·7	20·9	57·0	13·9	12·7	7·6	73·9	23·3	51·4	10·7	22·5	12·0
Bloemfontein	69·7	20·9	53·3	11·8	16·4	9·1	75·2	24·0	46·4	8·0	28·8	16·0
Pietersburg .	70·0	21·1	58·3	14·6	11·7	6·5	71·6	22·0	52·9	11·6	18·7	10·4

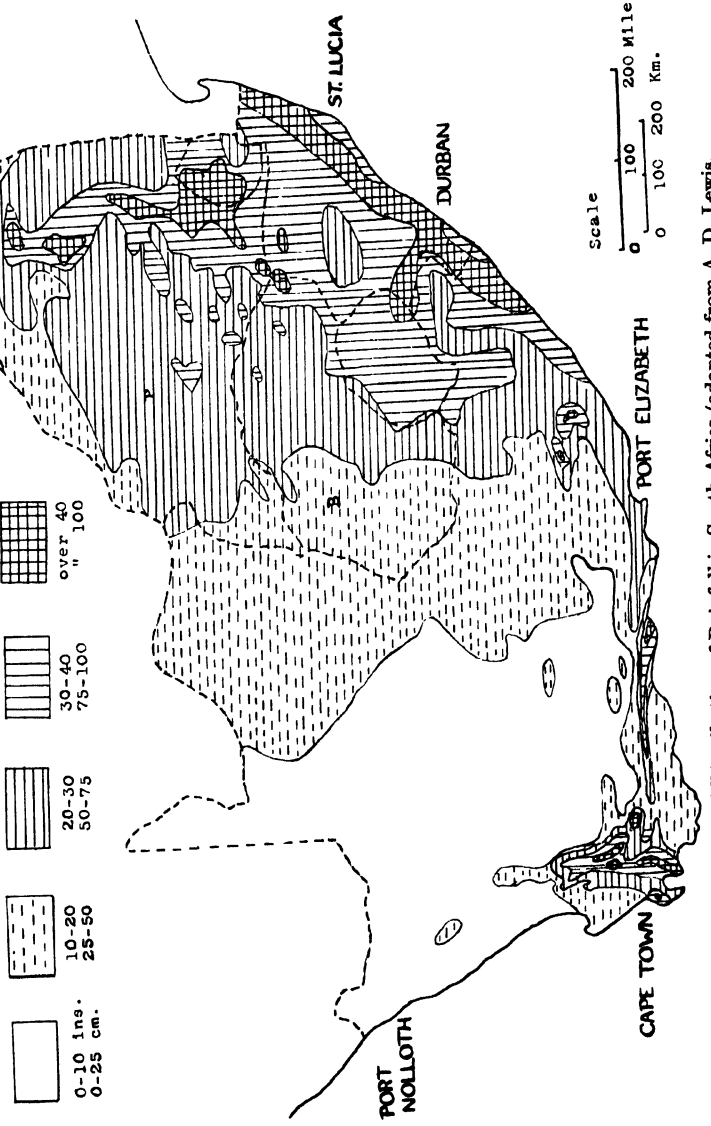
The country can be divided into two temperature regions: the coastal belt, where the range is small and frosts rare or absent, and the much larger interior, which has a large range and general occurrence of frost. Temperatures as low as 14° F. (− 10° C.) have been recorded in screens, and grass temperatures may be much lower. A temperature of 7° F. (− 13·6° C.) was recorded on the ground on a clear night in July at 4,800 feet (1,463 m.), and this is not exceptional. Such low temperatures are not prolonged and nearly always a rapid rise occurs in the daytime.

PRECIPITATION

Rainfall

From the standpoint of plant life and plant distribution rainfall is probably the most important of the climatic factors. The rainfall of the Union shows a large degree of variation both in amount and in distribution through the year. Over most of the country the total annual precipitation is rather small; nearly two-thirds receives less than 20 inches (50 cm.) and very large portions have less than 10 inches (25 cm.). Totals of less than 5 inches (12·7 cm.) are experienced over a far from negligible area. The line representing 20 inches (50 cm.) runs approximately due north from Port Alfred to the Limpopo valley. The whole country to the west of this has less except for the narrow coastal strip in the south and the mountain regions in the south-west (Map 4).

Regions with high rainfall, 60 inches (152 cm.) or over, are confined to the summits of the higher mountains such as the Drakensberg in Basutoland and on the Transvaal-Natal border, and the



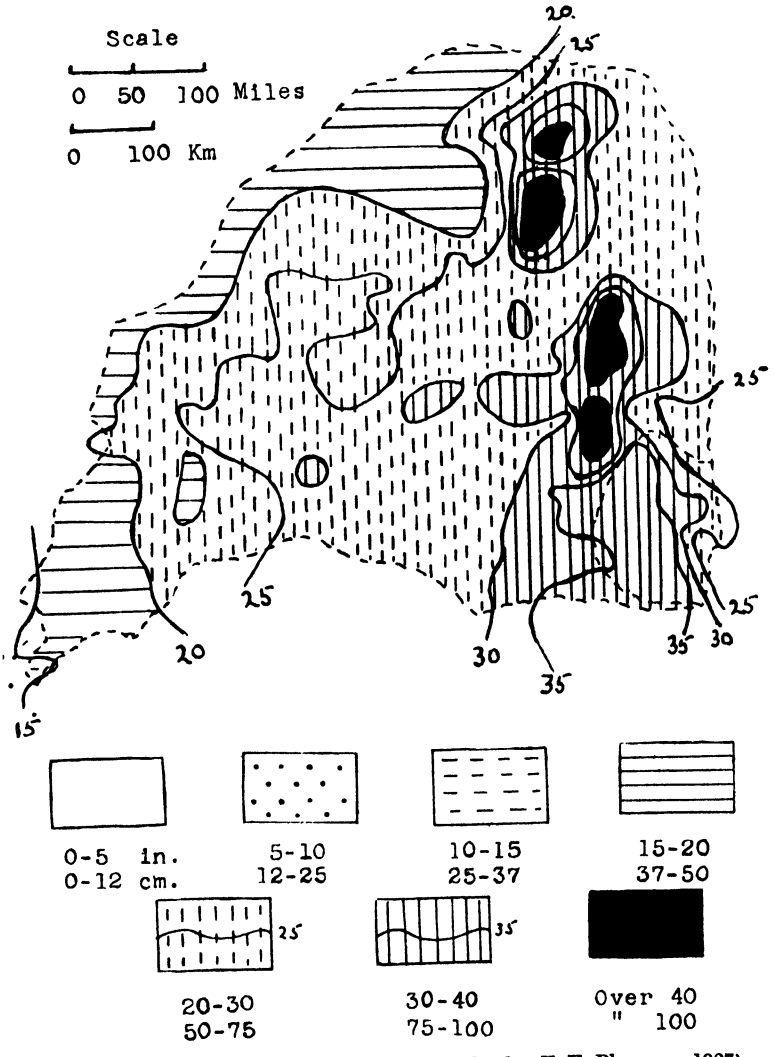
MAP. 4.—General Distribution of Rainfall in South Africa (adapted from A. D. Lewis, 1927). B = Bloemfontein, P = Pretoria.

coastal mountains in the south-west. Small areas with high rainfall also occur on the escarpment in the north-eastern Transvaal. Excluding these local and mountainous areas, the annual rainfall decreases from a maximum on the east coast as one passes westwards.

Apart from local deviations due to the larger surface features the lines of decreasing rainfall run approximately north and south from the east up to about the centre of the country. Further west their direction is less regular. Irregularities occur in a marked degree along the coastal strip. In general terms, areas with 40 inches or more (101 cm.) occupy the coastal plain of Natal from the northern boundary southwards to about the mouth of the Great Kei River. Other areas with this rainfall occur in the central south coast in the Zitzikama region and on mountain ranges. The line of 30 inches (76 cm.) outlines the foothills of the Drakensberg and associated mountains, including almost all Basutoland and Natal inland from the coast. This amount also occurs on the mountain slopes of the south-west, extending as far north as the Cedarberg. Other areas occur near Johannesburg and Pretoria and in parts of the high ground between the Crocodile River and the Limpopo (Maps 5, 6, 7).

The whole of the interior plateau west of the centre of the country, except the most elevated portions, has a precipitation under 10 inches (25 cm.). The regions with less than 5 inches (12·7 cm.) are in the lower course of the Orange River, large parts of Bushmanland, and portions of the west coast belt. There are smaller areas of very low rainfall between the Cedarberg and Roggeveld Mountains, and on the Great Karroo in the valleys of the Dwyka and Buffels Rivers. Map 4 (p. 21) indicates the general distribution of rainfall.

Rainfall Reliability.—Throughout the country there is a large degree of variation in amount of rainfall from year to year. The deviation from the normal is itself inconstant and irregular. This unreliability is least apparent on the coasts; in many of the drier inland places it is so great that short period averages are of little value. As an illustration of the phenomenon the figures for 1929 for a number of stations are compared with the averages in Table 7 (p. 25); the year 1929 is selected arbitrarily—it was in no way unusual.



MAP 5.—Distribution of Rainfall in the Transvaal (after F. E. Plummer, 1927).

TABLE 7.—*Rainfall (significant variations in italics)*

	Lat. °S. ° ′	Long. °E. ° ′	Altitude. ft.	m.	No. of Years Average.	Average Rainfall. in.	cm.	Rainfall, 1929. in.	cm.
Port Shepstone.	30 43	30 27	180	55	34	43·96	111·65	*69·26*	*175·92*
Durban . .	29 50	31 00	30	9	55	41·12	104·44	44·17	112·09
P.M.Burg. .	29 35	30 22	2,218	675	31	36·94	93·82	*44·38*	*112·72*
Bethlehem	28 14	28 18	5,300	1,615	22	23·72	60 24	*32 53*	*82·62*
Bloemfontein .	29 07	26 12	4,518	1,376	19	29·44	74·77	*24·85*	*63·11*
Kimberley .	28 44	24 46	4,042	1,232	35	17·76	45·11	19·17	48·59
Victoria West .	31 24	23 07	4,100	1,250	43	10·42	26 46	9·85	25·01
Worcester .	33 39	19 26	780	238	52	12 38	31·44	*8·99*	*22·78*
Cape Town .	33 56	18 29	40	12	85	25·28	64·21	*19·53*	*49·60*
Van Rynsdorp .	31 35	18 46	400	122	32	5·68	14·42	5 40	13·71

As a more detailed illustration of this unreliability factor, the totals for successive years for two stations are given in the accompanying table and graph. The one is the waterworks of the City of Cape Town at Steenbras on the coastal mountains in the west; the other the Karroo Garden of the National Botanic Gardens at Whitehill on the Great Karroo.

TABLE 8.—*Annual Totals of Rainfall at Steenbras Dam and Whitehill*

Year.	Rainfall at Steenbras Dam. in.	cm.	at Whitehill. in.	cm.
1916 .	45·97	116·16		
1917 .	49·59	125·95		
1918 .	43·9	111·5		
1919 .	38·15	96·9		
1920 .	48·43	123·43		
1921 .	40·28	102·31		
1922 .	31·6	80·26		
1923 .	50·05	127·12	5·38	13·66
1924 .	33·19	84·3	2·98	7·56
1925 .	37·2	94·48	7·29	18·51
1926 .	30·55	77·59	3·27	8·3
1927 .	28·43	72·21	2·52	6·2
1928 .	19·51	49·55	3·2	8·1
1929 .	26·43	67·13	5·25	13·33
1930 .	28·30	71·88	5·63	14·3
1931 .	29·11	73·94	3·72	9·29
1932 .	29·27	74·34	3·06	7·87
1933 .	26·03	66·11	4·47	11·35

The figures for Steenbras Dam are based on figures supplied by the City Engineer for Cape Town, those for Whitehill on figures supplied by Professor R. H. Compton, Director of the National Botanic Gardens.

The following graphs show the percentage deviation from the average for these two stations :—

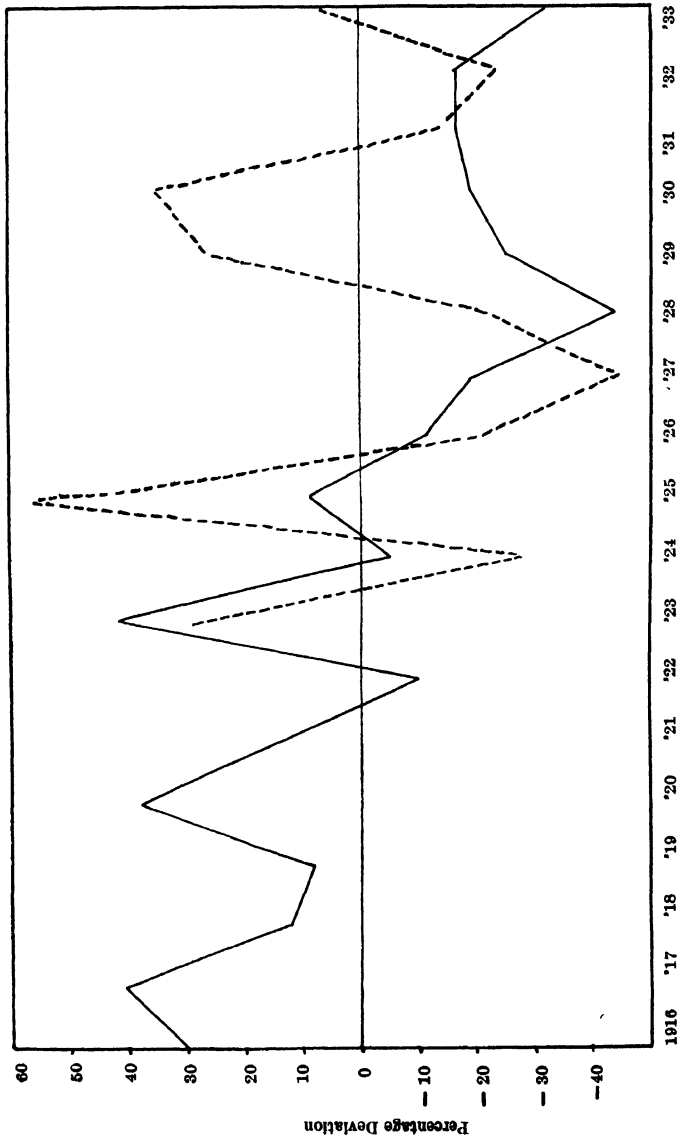
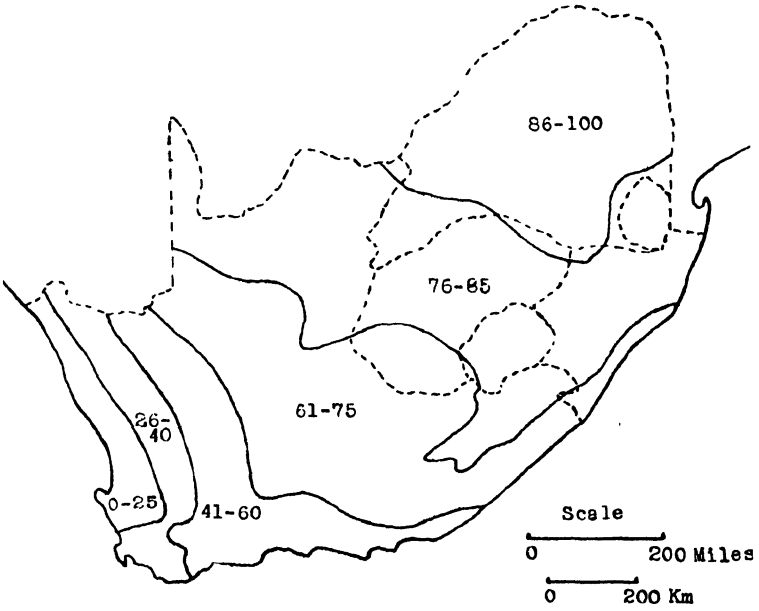


FIG. 1.—Graph showing percentage deviation from the average rainfall at Steenbras Dam (continuous line) and Whitehill (broken line).

In these two examples the rainfall at Steenbras might suggest a cyclic deviation, but this conclusion is not supported by the results from the Karroo station, which is less than 200 miles away. This rainfall unreliability, especially in the drier regions, is a factor of importance in connection with the development of the country and utilisation of the land. The prevalence of losses from drought is often due to deficiency of rainfall for a period on land where usage



MAP 8.—Seasonal Distribution of Rainfall in South Africa (after G. W. Cox). The figures represent the percentage of the total rainfall falling in the summer (October-March).

is based on the periods of more abundant rain. On grazing lands stocking is very often on the basis of " good years," and whenever the annual rainfall fails to reach this amount losses are experienced. The whole problem of the development of the drier regions with unreliable rainfall is one demanding careful investigation on the lines of scientific agriculture.

Seasonal Distribution.—Almost the whole country has a seasonal rainfall. Part of the year has little rain, sometimes practically none. Evenly distributed rain is confined to quite limited areas on the

coasts. Much the largest part of the country has most of the rainfall in the summer months with a dry winter. The percentage of the total falling in the winter decreases from the coast to the interior: on the east coast it may be 30–40 per cent., but only 10–15 per cent. in the upper part of the Limpopo valley.

A small region in the south-western Cape Province has a quite different distribution: here 60 per cent. or more falls in winter. The winter rains hardly extend beyond the coastal mountains; the country inland is arid. The following table of stations grouped geographically illustrates the varieties of seasonal distribution.

TABLE 9.—*Seasonal Distribution of Rainfall*

	Lat. °S.	Long. °E.	Altitude. ft.	Altitude. m.	Total Rainfall. in.	Total Rainfall. cm.	Percentage of Total Apr. to Sept.	Percentage of Total Oct. to Mar.	Rain Days. Apr. to Sept.	Rain Days. Oct. to Mar.
	° ′	° ′								
SOUTH-EAST										
East London	33 01	27 54	150	46	32·79	83 28	38	62	37	63
King Williamstown	32 52	27 23	1,315	401	21·50	54·61	31	69	24	44
Umtata	31 35	28 46	2,300	701	25 61	65 04	27	73	28	68
EAST COAST										
Durban	29 52	31 03	30	9	44·87	113 9	30	70	37	80
P.M.Burg	29 35	30 22	2,218	675	36 94	93 8	18	82	31	96
Paulpietersburg	27 27	30 52	3,729	1,136·5	36·73	93 29	16	84	20	75
NORTH-EAST LOWLANDS										
Barberton	25 47	31 03	2,885	878	32·95	83·68	15	85	16	57
Komatipoort	25 26	31 56	620	189	28·85	72 87	15	85	17	58
Bremersdorp (Swaziland)	26 29	31 23	2,200	670	37 83	96 08	16	84	18	64
LIMPOPO BASIN										
Nylstroom	24 42	28 25	3,735	1,138	25·00	66 50	13	87	11	56
Pietersburg	23 54	29 28	4,270	1,301	21·64	54·96	10	90	11	49
Louis Trichardt	23 03	29 54	3,120	951	31·40	79·75	14	86	24	63
HIGHLANDS (DRAKENSBERG, ETC.)										
Qacha's Nek	30 07	28 42	6,230	1,899	36 09	91 66	19	81	23	77
Wakkerstroom	27 21	30 08	5,780	1,762	32 52	82·60	14	86	21	73
Hogsback (Amatola)	32 36	27 02	6,373	1,942	29·53	75·00	27	73	—	—
INTERIOR PLATEAU.—1. EASTERN										
Kroonstad	27 14	27 40	4,300	1,311	24·21	61·49	19	81	15	53
Pretoria	25 45	28 12	4,471	1,363	29·45	74·80	12	88	15	74
Mafeteng (Basutoland)	29 49	27 14	5,600	1,706	31 34	79·6	25	75	22	58
INTERIOR PLATEAU.—2. CENTRAL										
De Aar	30 39	20 01	4,079	1,243	12 75	32 36	30	70	14	25
Kimberley	28 44	24 46	4,042	1,232	15 86	40·17	23	77	18	44
Vryburg	26 57	24 44	3,890	1,185	19·24	48·86	16	84	10	40
INTERIOR PLATEAU.—3. WESTERN										
Fraserburg	31 55	21 31	4,200	1,280	6 82	17·32	41	59	15	16
Upington	28 25	21 15	2,800	853	7·24	18·38	26	74	9	16
Calvinia	31 29	19 46	3,500	1,067	8·46	21·48	68	32	24	11

	Lat. °S.	Long. °E.	Altitude. ft.	Altitude. m.	Total Rainfall. in.	Total Rainfall. cm.	Percentage of Total Apr. to Sept.	Percentage of Total Oct. to Mar.	Rain Days. Apr. to Sept.	Rain Days. Oct. to Mar.
	° ′	° ′								
West Coast										
Van Rhynsdorp	31 35	18 46	400	122	5 68	14·42	80	20	27	9
Garies	30 33	17 59	830	253	5·29	13 53	80	20	17	7
Port Nolloth	29 14	16 55	24	7	2 46	6 24	78	22	16	8
South-West										
Cape Town	33 56	18 29	40	12	25 28	64 21	77	23	65	32
Bredasdorp	34 33	20 02	250	76	20 22	51 35	60	40	48	33
Ceres	33 22	19 19	1,500	457	41 52	105 4	78	22	47	20
South Coast										
Storms River	33 58	23 52	580	177	44 46	112·9	48	52	56	69
Pt Elizabeth	33 58	25 37	176	54	22 30	56 64	54	46	36	40
Grahamstown	33 18	27 23	1,769	539	21 50	54 61	31	69	34	44

The unreliability of rainfall affects the seasonal distribution, and especially so in the drier places. As an example, the total precipitation at Kakamas on the Orange River averages 5·98 inches (15·19 cm.): for four consecutive years 89 per cent. was received during the period December-May; in the following year the percentage for this period fell to 52. As a more complete illustration, the monthly averages of three stations are compared with the rainfall figures for 1929 in the following table (significant differences are in italics):—

TABLE 10.—*Monthly Rainfall Averages of Three Stations Compared with the Rainfall for* 1929

	Bloemfontein (15 Years). Av. in.	Bloemfontein (15 Years). 1929 in.	Bloemfontein (15 Years). Av. cm.	Bloemfontein (15 Years). 1929 cm.	Venterstad (Cape) (42 Years). Av. in.	Venterstad (Cape) (42 Years). 1929 in.	Venterstad (Cape) (42 Years). Av. cm.	Venterstad (Cape) (42 Years). 1929 cm.	Carnarvon (47 Years). Av. in.	Carnarvon (47 Years). 1929 in.	Carnarvon (47 Years). Av. cm.	Carnarvon (47 Years). 1929 cm.
Jan.	3 56	*2 29*	9 04	*5·81*	2·13	1·77	5 41	4 49	0·95	*0·00*	2·41	*0·00*
Feb.	3·26	*0 50*	8 28	*1 27*	2 86	*0 30*	7 26	*0 76*	1 37	*0 06*	3·47	*0·15*
Mar.	3 07	*4 36*	7 79	*11 07*	3·28	*2 44*	8 33	*6·19*	1·60	*2·51*	2·69	*6·37*
Apr.	1·00	0 63	2·54	1·60	1·67	*0 49*	4 24	*1·24*	0 92	1 16	2·33	2·94
May	0·81	0·53	2 05	1 34	1 08	0·88	2·74	2 23	0 64	*0·24*	1·62	*0 60*
June	0 17	*1·97*	0 43	*5 00*	0·70	0·93	1·77	2 36	0 35	0·25	0·88	0·63
July	0·47	*0 88*	1·19	*2 23*	0 40	0 60	1 01	1·52	0 23	0·31	0·58	0 78
Aug.	0·49	0 38	1 24	0 96	0·47	*0·87*	1·19	*2 20*	0·28	*2 03*	0·71	*5·15*
Sept.	1 07	*3 52*	2 71	*8 94*	0·73	*6·19*	1 85	*15·72*	0 30	*1·59*	0·76	*4 03*
Oct.	1 81	*0 69*	4 59	*1 75*	2 04	*0 32*	5·18	*0 81*	0 40	0 52	1 01	1·32
Nov.	2 06	2 19	5 23	5·56	1·43	*0 51*	3 36	*1 29*	0·58	*0 00*	1·32	*0 00*
Dec.	2 13	*4 49*	5·41	*11·40*	1·82	*3 01*	2 67	*7·64*	0 47	0·13	1·19	0·33
Total	19·90	22 43	10 54	56 97	18·61	18 31	47·26	46·40	8 09	8·80	20·54	22·35

Intensity of Rainfall.—Over much of the interior of the country the rain, or a large proportion of it, falls in heavy storms of short duration. These rainstorms are very often associated with thunder. This feature is brought out in the small numbers of rain-days in the preceding tables. These heavy, short rains are most prevalent in the summer, the winter rains frequently come as light showers.

Excessive downpours, in the nature of cloudbursts, are not very common.

Hail.—Precipitation in the form of hail is fairly common and generally connected with thunder. Hailstorms are not frequent on the coasts, but are prevalent over the interior in summer. These hailstorms may do quite severe damage locally. The hailstones may be of large size and weight, and may break roofing tiles, damage crops and trees. Cases are recorded of sheep being killed by hailstones of large size.

Snow.—Snow is of regular occurrence in the mountains, but rarely persists for more than a few days. On the coastal mountains snow falls regularly at heights of over 4,000 feet (1,219 m.), but only lasts at levels over 6,000 feet (1,828 m.). Snowfalls may occur over any part of the interior plateau during specially cold periods accompanying rapid barometric depression. Such falls are transitory and rarely persist even for twenty-four hours. It is only on the highest parts of the mountains that snow can be regarded as a factor influencing the vegetation.

RELATIVE HUMIDITY

Unfortunately few figures are available for humidity that are of significance for determination of conditions affecting vegetation. The usual practice in meteorological observations is to take readings at 8 a.m.; for vegetation it is the extremes that are of importance. Throughout the country humidity falls to low values during the day. Mid-day readings are available for Kopje Alleen in the Bushveld vegetation in the Transvaal: the mean value at 3.30 p.m. is 37; for the summer months 43, and for winter 31.

Lower figures are often obtained in the drier regions. For example, the following values were obtained in shade, sheltered from wind, on successive days on the Upper Karroo: 60, 30, 44, 39·5, 34·5, 30, 25·5, 43. The observations were taken at 1.30 p.m. These figures were obtained during a period of rather cold weather and do not represent at all extreme values. Readings below 15 have been made in arid districts in spring.

EVAPORATION

Records of evaporation are kept at a number of irrigation and water conservation stations. The following table gives the figures for evaporation from tanks and the rainfall:—

TABLE 11.—*Evaporation (from Tanks) and Rainfall*

	Altitude. ft.	Evaporation. Apr.–Sept. in.	Evaporation. Oct.–May. in.	Rainfall. Apr.–Sept. in.	Rainfall. Oct.–May. in.
South-Western Cape.					
Table Mountain	2,496	9·05	25·07	28·15	10·41
Steenbras	—	10·99	35·42	26·11	9·07
Elsenberg	400	25·76	64·01	19·53	5·21
Karroo.					
Kamanassie Dam	1,100	19·59	50·56	5·33	3·70
Graaff Reinet	2,550	24·46	54·14	4·81	9·51
Grootfontein	4,130	19·12	46·19	3·51	10·57
South-Eastern Karroo Border.					
Lake Arthur (Tarka Riv.)	—	26·46	49·17	3·63	6·84
Lake Mentz (Sunday Riv.)	800	19·26	51·02	4·24	7·14
South-Eastern Cape.					
Stutterheim	2,945	31·37	32·59	7·77	21·82
High Veld.					
Johannesburg	5,735	23·18	29·98	4·00	26·45
Hartebeestpoort	4,000	25·51	36·39	6·25	24·76
Northern Transvaal.					
Kopje Alleen	3,488	28·43	41·01	2·76	23·49

	m.	cm.	cm.	cm.	cm.
Table Mountain	758	22·98	63·67	71·5	26·4
Steenbras	—	27·91	89·96	66·31	23·03
Elsenberg	122	65·43	162·58	48·60	13·23
Kamanassie Dam	334	49·75	128·42	13·53	9·39
Graaff Reinet	777	62·12	137·51	12·21	24·15
Grootfontein	1,258	48·56	117·32	8·91	26·84
Lake Arthur	—	67·20	124·89	9·19	17·37
Lake Mentz	243	48·92	129·59	10·76	18·18
Stutterheim	897	79·57	82·77	19·73	55·42
Johannesburg	1,746	58·87	76·14	10·16	67·18
Hartebeestpoort	1,219	64·79	92·43	15·87	62·89
Kopje Alleen	1,063	72·21	104·16	6·01	59·66

From the above table it will be apparent that, with very few exceptions, the evaporation rate exceeds the precipitation, in the drier parts by a considerable amount. The only station in the table where evaporation is less than precipitation is Table Mountain, and even here in summer evaporation is 2·5 times the rainfall. The excess of evaporation occurs in both the wet and the dry seasons in most cases. The high value for evaporation and the tendency for so much of the rain to be concentrated in short heavy storms very much reduces the value of the total for the vegetation. The

moisture from small showers is often lost by evaporation before it can penetrate the ground.

CLOUD

The general amount of cloud in the sky is not great. Clear cloudless skies are common over the whole country at all seasons. Even during the wet periods skies that are overcast for long are of rare occurrence. Two days without sun are exceptional. This absence of cloud accompanies a high percentage of possible sunlight. At Cape Town the percentage is 66, at Johannesburg 73, and at Kimberley 78.

The following table gives figures, as monthly averages, for cloudiness in stations from the different vegetation types. The figures are on a scale 0 -10 for the amount and density of cloud : —

TABLE 12.—*Cloudiness*

Vegetation Type	Station.	Annual Value.	Summer Value.	Winter Value.
Sclerophyll . .	Cape Town .	3·4	2·4	4·4
Temperate Forest .	Deepwalls .	5·2	5·4	4·9
Warm Temp. Forest.	East London .	5·4	5·8	4·9
Sub-trop. Forest .	Durban . .	4·7	5·7	3·6
Montane Forest .	Graskop . .	4·7	6·5	2·9
Temp. Savanna .	Queenstown .	4·8	5·4	4·2
Low Veld . .	Komatipoort .	5·1	6·3	2·8
Bush Veld . .	Kopje Alleen .	3·4	5·1	1·7
Bush Savanna .	Postmasburg .	2·6	2·6	2·8
Grassland . .	Bloemfontein .	3·8	3·9	3·6
Arid Bush . .	Carnarvon .	3·3	2·2	4·4
Succulent Bush .	Willowmore .	2·6	2·5	2·6
	O'okiep . .	2·8	1·9	2·6
Coast Succ. Bush .	Port Nolloth .	5·1	5·2	4·9

REGIONAL CLIMATES

In the following pages the principal features of the climates in the regions of the various types of vegetation are set out in a summarised form. To obtain a picture of the climatic environment of any vegetation all the factors should be studied : it is the resultant action that is important. In the present account only those factors on which data are available—altitude, rainfall and temperature—

are dealt with. Humidity and evaporation, both of which are of great importance, are recorded at so few places that generalisations are out of the question. Though only a few factors have been dealt with, it is clear that the interactions are very important: no single factor will give an explanation of the distribution of the vegetation.

It has to be remembered that the types of vegetation are not sharply separated from one another but intergrade: the climatic conditions in the transitional zones are intermediate between those of the types themselves. In this summary the climatic characters given are those found where the vegetation is typically developed. The extremes are not always included.

Note on the Tables and Charts.—In the tables altitude, rainfall and temperature are given both in British and metric measures. Altitude is given in feet and metres; rainfall in inches and centimetres; temperature in degrees Fahrenheit and centigrade; mean temperatures are averages of the monthly means for the six-month periods. The temperature range is the difference between the mean monthly maximum and mean monthly minimum. The last line in the tables gives the average number of months in which temperature falls below the freezing point.

In addition to the tables, a number of so-called "hydrotherm charts" for characteristic examples in each type are appended. In these the rainfall (broken line) is given in centimetres and temperature (continuous line) in degrees centigrade.

1. **Sclerophyll.**—This occurs in the south-western part of the Cape Province. The vegetation area ranges in altitude from sea-level to over 7,000 feet (2,130 m.), though the country over 2,500 feet (762 m.) is all mountainous. The whole has definite winter rainfall. The total varies from 12 to 70 or 80 inches (30 to 175–200 cm.) and of this 60–80 per cent. falls in winter. Excluding the higher mountains, the rainfall averages 16–50 inches (40–127 cm.). The mean temperature in summer is between 62°–69° (17°–20° C.) and in winter 50°–58° F. (10°–14° C.). The temperature range is low at the coast but increases inland, where both higher summer temperatures and lower winter ones occur. Frosts are unknown at the coast but occur inland and at the higher altitudes. Even at 2,496 feet (758 m.) on Table Mountain frosts are not of at all regular

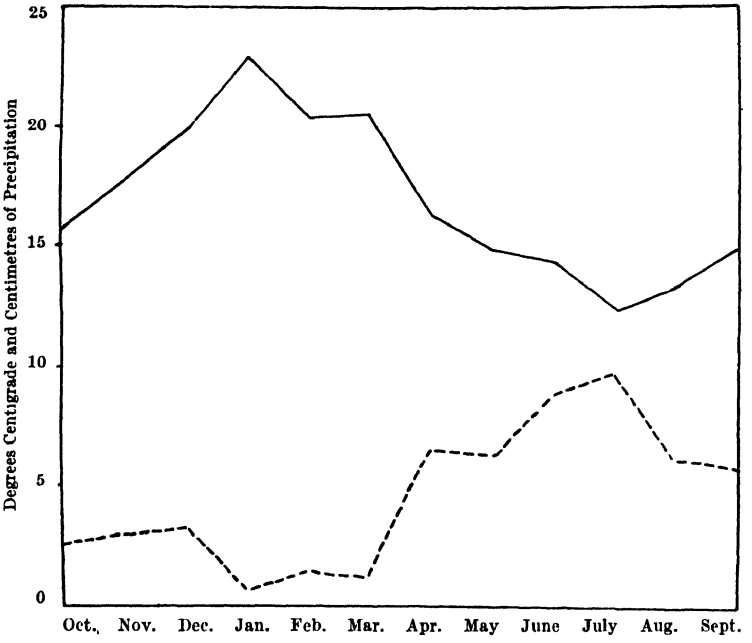


FIG. 2.—Hydrotherm Chart of Sclerophyll Climate (Cape Town). See p. 33.

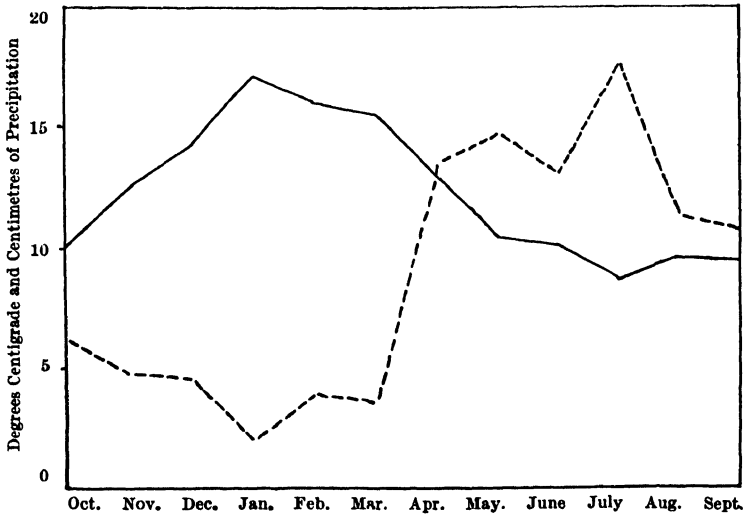


FIG. 3.—Hydrotherm Chart of Upland Sclerophyll Climate (Table Mountain). See note on p. 33.

occurrence. Average mean minimum temperatures in winter are 42°–51° F. (5·5°–10·5° C.).

TABLE 13.—*Sclerophyll*

		Darling.	Cape Town.	Table Mt.	Ceres	Elgin.	Riversdale.	O'okiep.
		° ′	° ′	° ′	° ′	° ′	° ′	° ′
Latitude S.		33 22	33 56	33 59	33 22	34 09	34 06	29 36
Longitude E.		18 23	18 29	18 24	19 19	19 01	21 16	17 52
Altitude	ft.	378	40	2,496	1,500	919	200	3,060
	m.	115	12	758	457	280	61	932
Rainfall:								
Apr.–Sept.	in.	17·37	19·55	28·15	32·43	37·87	8·72	5·15
	cm.	44·11	49·65	71·5	82·3	96·18	22·1	13·08
Oct.–Mar.	in.	3·77	5·73	10·41	9·09	10·06	8·37	1·75
	cm.	9·57	14·55	26·4	23·0	25·5	21·2	4·44
Rain Days.								
Apr.-Sept.		63	65	91	47	66	47	29
Oct.–Mar.		27	32	62	20	39	38	12
Mean Temperature:								
Apr.–Sept.	°F.	58·1	58·3	50·4	54·4	54·4	57·8	59·2
	°C.	14·5	14·6	10·2	12·4	12·4	14·3	15·0
Oct.–Mar.	°F.	68·9	67·8	57·5	69·0	62·4	67·6	70·1
	°C.	20·5	19·19	14·1	20·5	16·9	19·8	21·1
Mean Min. Temp.:								
Apr.–Sept.	°F.	49·4	51·1	44·6	41·9	41·9	44·7	48·8
	°C.	9·6	10·6	7·0	5·5	5·5	7·0	9·3
Oct.–Mar.	°F.	57·3	58·4	50·2	54·5	49·9	57·8	50·4
	°C.	14·0	14·7	10·1	12·5	9·9	14·3	10·2
Temp. Range:								
Mean Annual	°F.	23·4	35·7	29·3	55·9	44·4	44·0	—
	°C.	13·0	19·7	16·3	31·0	24·7	24·4	—
Mean Winter	°F.	17·8	24·3	20·0	36·0	34·7	37·0	—
	°C.	9·8	13·5	11·1	20·0	19·3	20·5	—
Mean Summer	°F.	18·0	28·1	27·3	40·5	37·6	33·0	41·9
	°C.	10·0	15·6	15·1	22·5	20·2	18·3	23·2
Months with Frost		0	0	(rare)	4	6	2	(rare)

2. **Temperate Forest.**—Forest land on the south coast extends from sea-level to 2,000 feet (610 m.) or higher under specially sheltered conditions. The rainfall is 35–45 inches (88–114 cm.) and more or less evenly distributed through the year, with no definite or prolonged dry period. Temperatures are rather uniform; the summer mean is 63°–64° F. (17·2°–17·7° C.); the winter mean 54°–57° F. (12·2°–13·9° C.). The annual range is 27°–31° F. (15°–17° C.). Frosts do not occur at all.

TABLE 14.—*Temperate Forest*

		George.	Deepwalls.	Harkerville.	Storms River.
		° ′	° ′	° ′	° ′
Latitude S.		33 57	33 35	34 03	33 58
Longitude E.		22 29	23 10	23 12	23 52
Altitude	ft.	880	1,750	550	735
	m.	268	533	167	224
Rainfall:					
Apr.–Sept.	in.	14·80	21·39	19·40	21·31
	cm.	37·57	54·33	49·27	54·02
Oct.–Mar.	in.	19·42	23·27	19·85	23·15
	cm.	49·32	59·10	50·41	58·7
Rain Days:					
Apr.–Sept.		56	66	48	56
Oct.–Mar.		67	79	50	69
Mean Temp.:					
Apr.–Sept.	°F.	57·0	57·3	54·0	57·1
	°C.	13·9	14·0	12·2	13·95
Oct.–Mar.	°F.	63·6	64·1	64·1	63·5
	°C.	17·5	17·8	17·8	17·5
Mean Min. Temp.:					
Apr.–Sept.	°F.	48·2	41·1	41·1	48·1
	°C.	8·9	5·0	5·0	8·9
Oct.–Mar.	°F.	54·9	54·0	57·3	54·8
	°C.	12·7	12·2	14·0	12·6
Mean Temp. Range:					
Annual	°F.	30·7	27·6	31·5	31·8
	°C.	17·1	15·3	17·5	17·6
Apr.–Sept.	°F.	27·6	23·4	27·6	28·9
	°C.	15·3	13·0	15·3	16·1
Oct.–Mar.	°F.	24·9	24·9	26·1	25·0
	°C.	13·8	13·8	14·5	13·8
Months with Frost		0	0	0	0

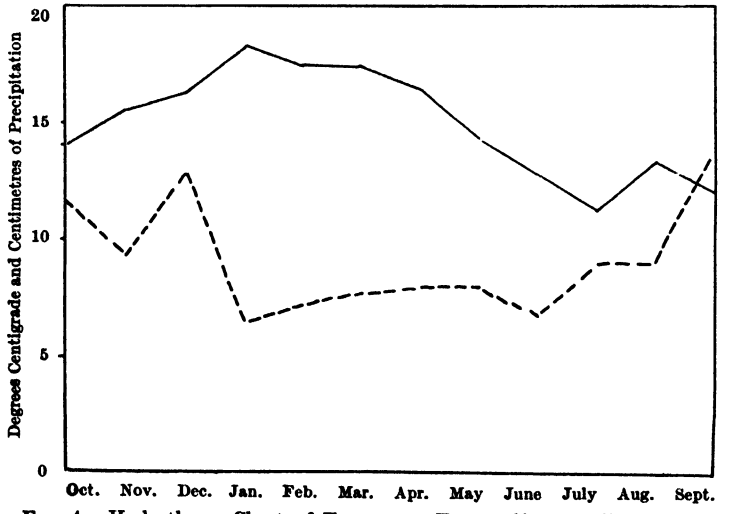


FIG. 4.—Hydrotherm Chart of Temperate Forest Climate (Deepwalls).

3. **Warm Temperate Forest.**—Forest occurs from sea-level to 1,250 feet (380 m.) or higher in favoured localities. The rainfall is 48–50 inches (121–127 cm.), though in the western parts as little as 15–16 inches (38–40 cm.) may occur. About 60 per cent. falls in the summer. Temperatures are higher than in the previous type; the summer mean is 68°–70° F. (20°–21° C.), and the winter mean 59°–65° F. (15°–18° C.). The range is greater than in the previous type, but is not high, 23°–43° F. (13°–23° C.). Frosts do not occur.

TABLE 15.—*Warm Temperate Forest*

		King Williamstown.	East London.	Port St. Johns.	Ultenhage.
		° ′	° ′	° ′	° ′
Latitude S. . . .		33 52	33 01	31 38	33 54
Longitude E. . .		27 23	27 54	29 35	25 24
Altitude . .	ft.	1,315	149	153	170
	m.	401	45	46	51
Rainfall:					
Apr.–Sept. .	in.	8·35	12·44	15·88	7·75
	cm.	21·21	31·59	40·33	19·68
Oct.–Mar. .	in.	16·87	20·35	33·19	9·43
	cm.	42·84	51·68	54·30	23·94
Rain Days:					
Apr.–Sept. .		35	37	34	28
Oct.–Mar. .		61	63	77	33
Mean Temp.:—					
Apr.–Sept. .	°F.	60·5	61·6	65·8	59·5
	°C.	15·8	16·4	18·7	15·2
Oct.–Mar. .	°F.	69·3	68·1	70·8	68·9
	°C.	20·7	20·0	21·5	20·5
Mean Min. Temp.:					
Apr.–Sept. .	°F.	47·5	56·0	59·6	47·1
	°C.	8·6	13·3	15·3	8·3
Oct.–Mar. .	°F.	58·3	62·6	64·6	57·5
	°C.	14·6	17·0	18·1	14·1
Mean Temp. Range:					
Annual . .	°F.	42·8	28·2	23·7	42·9
	°C.	23·7	15·6	13·1	23·8
Apr.–Sept. .	°F.	39·5	25·0	21·6	39·4
	°C.	21·9	13·8	12·0	21·8
Oct.–Mar. .	°F.	30·2	19·6	17·6	30·5
	°C.	16·6	10·8	9·7	16·8
Months with Frost . .		0	0	0	0

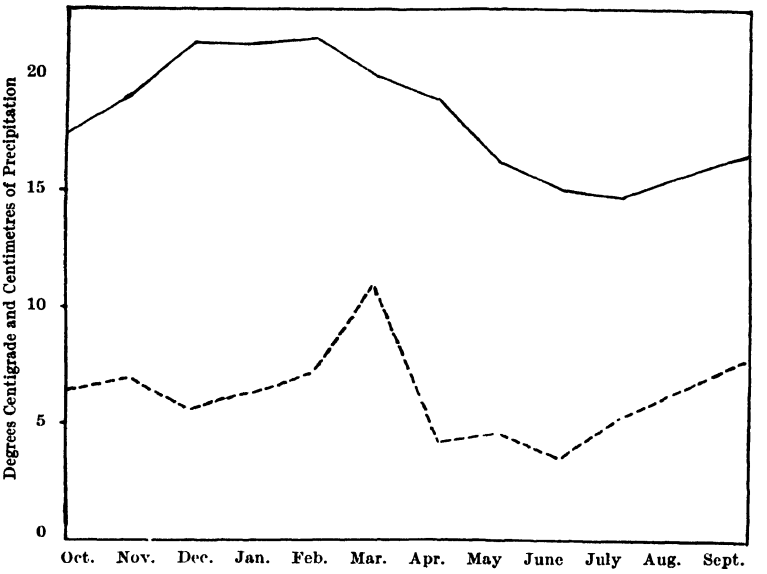


FIG. 5.—Hydrotherm Chart for Warm Temperate Forest Climate (East London). Continuous line—mean monthly temperature (°C.); broken line—mean monthly rainfall (cm.).

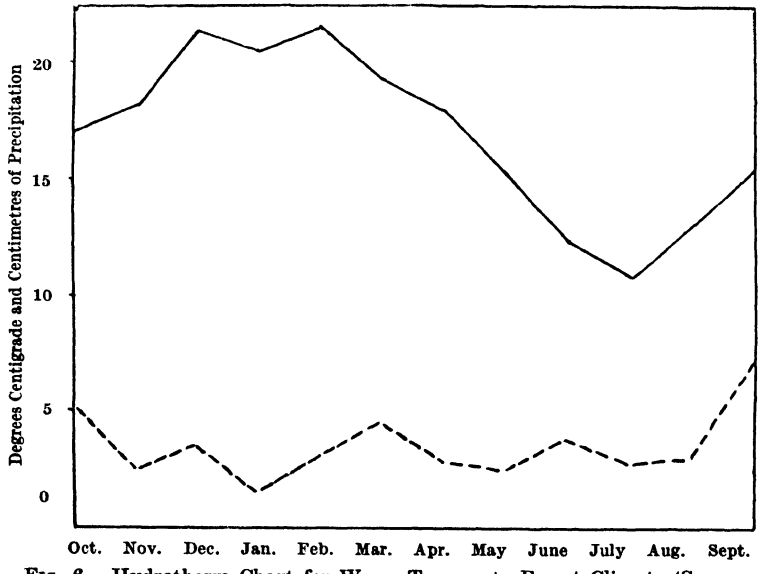


FIG. 6.—Hydrotherm Chart for Warm Temperate Forest Climate (Succulent Scrub—Uitenhage). Continuous line—mean monthly temperature (°C.); broken line—mean monthly rainfall (cm.).

4. **Sub-tropical Forest.**—This occurs on the low-lying strip along the Natal coast, where high rainfall and high temperature produce almost tropical conditions even in latitudes well outside the tropic itself. The type is confined to low-lying country nowhere over 1,000 feet (300 m.) and only occurs close to the coast.

The rainfall is 40–50 inches (102–127 cm.), though parts have only 35 inches (90 cm.). About 60–70 per cent. of the rain falls in summer, but there is no prolonged or distinct dry season. Temperatures are high and rather uniform, the mean winter temperature is not below 64° F. (17·7° C.), while in summer monthly means rise above 70° F. (21° C.). The annual range is 27°–33° F. (15°–18° C.). There is never frost.

TABLE 16.—*Sub-tropical Forest*

		Cape St. Lucia.	Amatikulu.	Durban.	Empangeni.	Port Shepstone.
		° ′	° ′	° ′	° ′	° ′
Latitude S.		28 31	29 02	29 50	28 46	30 43
Longitude E.		32 24	31 32	31 00	31 55	30 27
Altitude	ft.	375	350	30	210	180
	m.	114	106	9	64	55
Rainfall:						
Apr.–Sept.	in.	17·90	9·55	13·41	13·95	13·70
	cm.	45·46	24·25	34·06	35·43	34·79
Oct.–Mar.	in.	37·07	26·33	31·46	32·35	30·26
	cm.	94·15	66·87	80·06	82·16	76·91
Rain Days:						
Apr.–Sept.		48	32	37	37	30
Oct.–Mar.		79	74	80	64	71
Mean Temp.:						
Apr.–Sept.	°F.	66·9	66·9	66·6	66·0	64·3
	°C.	19·4	19·4	19·2	18·8	17·9
Oct.–Mar.	°F.	75·6	74·5	73·4	73·7	71·5
	°C.	24·2	23·6	23·0	23·1	21·9
Mean Min. Temp.:						
Apr.–Sept.	°F.	59·0	58·0	59·3	56·9	57·3
	°C.	15·0	14·4	15·1	13·8	14·0
Oct.–Mar.	°F.	67·6	66·1	67·3	65·8	64·6
	°C.	19·7	18·9	19·6	18·7	18·0
Temp. Range:						
Annual	°F.	30·4	35·4	27·3	33·8	27·0
	°C.	16·9	19·6	15·1	18·7	14·0
Apr.–Sept.	°F.	25·0	28·3	23·7	27·9	23·0
	°C.	13·8	15·7	13·1	15·5	12·7
Oct.–Mar.	°F.	—	25·6	18·0	23·5	17·6
	°C.	—	14·2	10·0	13·0	9·7
Months with Frost		0	0	0	0	0

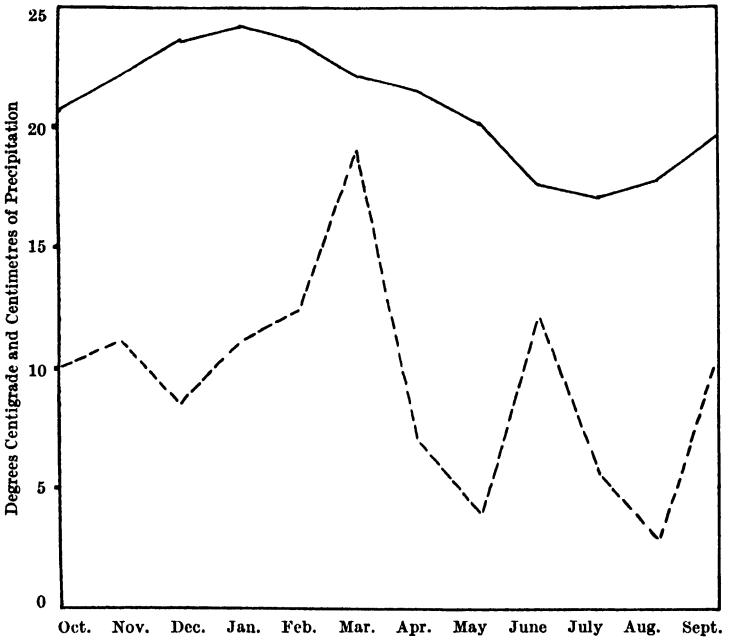


FIG. 7.—Hydrotherm Chart for Sub-tropical Forest Climate (Durban). Continuous line—mean monthly temperature (°C.); broken line—mean monthly rainfall (cm.).

5. **Montane Forest.**—This is confined to the slopes of the higher mountains in the northern parts of the Transvaal. Forests do not occur below 4,500 feet (1,370 m.). The rainfall is 60 inches (152 cm.) or more, of which 80–85 per cent. is in summer. Mists are frequent both in summer and winter. The mean temperature is low: 62°–63° F. (16·5°–17° C.) in summer, and 54°–55° F. (12°–12·5° C.) in winter. The mean minimum may fall below 40° F. (4·4° C.). The annual temperature range is 30°–34° F. (16·5°–18·5° C.). Frosts occur in the region in winter but not in the forests themselves.

TABLE 17.—*Montane Forest*

	Woodbush.	Graskop.	Mariepskop.	Entabeni.
	° ′	° ′	° ′	° ′
Latitude S. . . .	23 51	24 56	24 35	23 00
Longitude E. . . .	29 59	30 50	30 50	30 15
Altitude . . ft.	4,900	4,880		
m.	1,493	1,487		

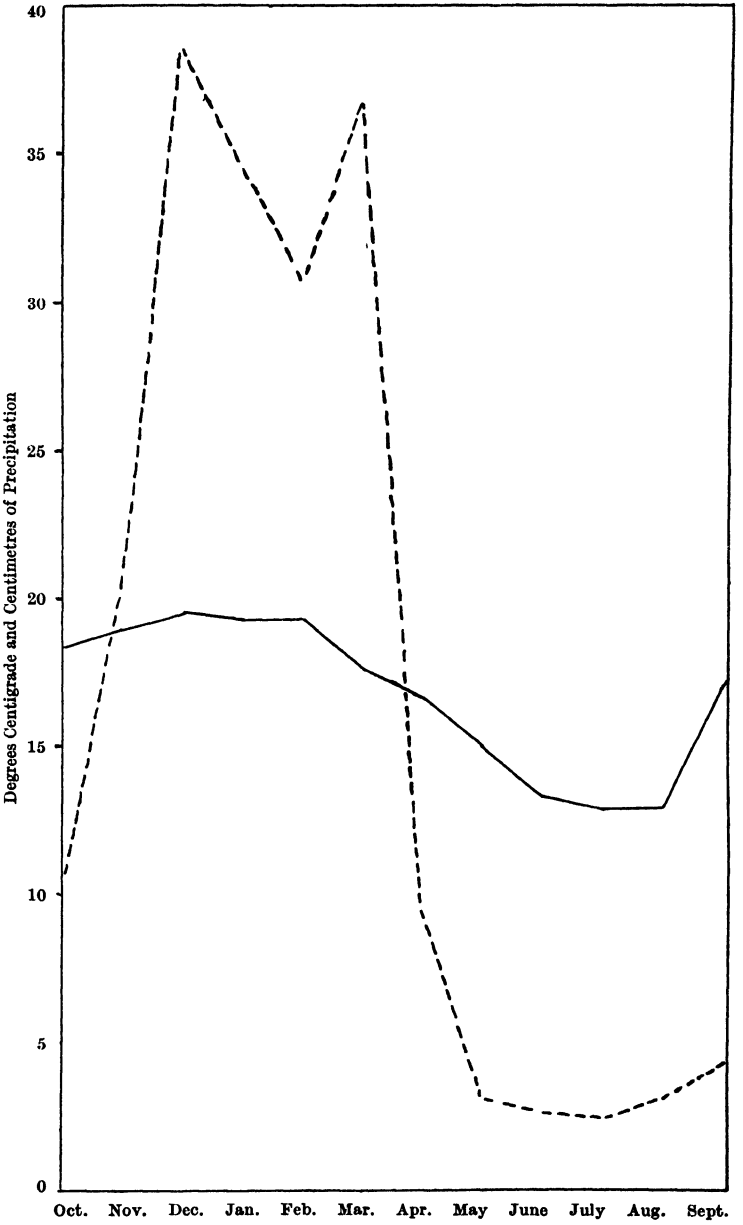


FIG. 8.—Hydrotherm Chart for Montane Forest Climate (Woodbush).

		Woodbush.	Graskop.	Mariepskop.	Entabeni.
Rainfall:					
Apr.–Sept.	in.	9·59	11·94	8·58	12·65
	cm.	24·35	30·32	21·79	32·13
Oct.–Mar.	in.	62·63	60·78	50·92	76·96
	cm.	159·08	154·48	129·33	193·7
Rain Days:					
Apr.–Sept.		31	44	19	33
Oct.–Mar.		93	105	72	79
Mean Temp.:					
Apr.–Sept.	°F.	54·8	54·8		
	°C.	12·6	12·6		
Oct.–Mar.	°F.	62·6	62·8		
	°C.	17·0	17·1		
Mean Min. Temp.:					
Apr.–Sept.	°F.	44·7	44·1		
	°C.	7·0	6·7		
Oct.–Mar.	°F.	55·2	53·8		
	°C.	12·9	12·1		
Mean Temp. Range:					
Annual	°F.	30·9	33·9		
	°C.	16·8	18·8		
Apr.–Sept.	°F.	29·0	29·5		
	°C.	16·1	16·3		
Oct.–Mar.	°F.	19·8	20·3		
	°C.	11·0	11·2		
Months with Frost		1–2	2–4		

6. **Temperate Savanna.**—This occupies most of the country between the escarpment mountains and the coast in the south-east portion. It covers much of the eastern Cape Province and of Natal, extending from sea-level up to altitudes of 4,000 feet (1,220 m.). The rainfall in this area is 20–40 inches (50–100 cm.), of which 75–80 per cent. is in summer; the winter is dry. Summer temperatures are moderately high, 65°–70° F. (18°–21° C.), with much lower ones in winter, 44°–59° F. (6·6°–15° C.). The annual range is greater than in the previously described types, 40°–52° F. (22°–28·8° C.). Frosts are of general occurrence in the winter months but are not severe. The frequency and duration of the frost period increases from the coast inland.

TABLE 18A.—*Temperate Savanna. Cape*

	Grahamstown.	Lovedale.	Queenstown.	Cala.	Umtata.
	° ′	° ′	° ′	° ′	° ′
Latitude S.	33 18	32 46	31 54	31 31	31 35
Longitude E.	26 32	26 31	26 52	27 40	28 46
Altitude ft.	1,769	1,760	3,550	4,000	2,300
m.	539	536	1,082	1,219	701
Rainfall:					
Apr.–Sept. in.	10·97	7·90	5·42	5·01	6·89
cm.	27·86	20·06	13·76	12·72	17·50
Oct.–Mar. in.	17·24	16·20	18·05	18·96	18·72
cm.	43·78	41·14	45·84	48·15	47·54

		Grahamstown.	Lovedale.	Queenstown.	Cala.	Umtata.
Rain Days :						
Apr.–Sept.		35	33	28	23	28
Oct.–Mar.		54	54	59	55	68
Mean Temp. :						
Apr.–Sept.	°F.	56·6	58·8	55·1	55·1	58·0
	°C.	13·7	14·9	12·8	12·8	14·4
Oct.–Mar.	°F.	64·4	69·6	67·9	65·6	67·7
	°C.	18·0	20·9	19·9	18·6	19·8
Mean Min. Temp. :						
Apr.–Sept.	°F.	44·6	46·1	42·1	43·9	46·5
	°C.	7·0	7·8	5·6	6·6	8·0
Oct.–Mar.	°F.	53·3	56·4	54·3	53·6	57·4
	°C.	11·8	13·5	12·4	12·0	14·1
Mean Temp. Range :						
Annual	°F.	42·2	47·8	52·1	45·1	46·4
	°C.	23·4	26·5	28·9	25·0	25·7
Apr.–Sept.	°F.	38·6	41·5	43·2	37·2	42·7
	°C.	21·4	23·1	24·0	20·6	23·7
Oct.–Mar.	°F.	32·8	36·2	37·1	33·2	29·4
	°C.	18·2	20·1	20·6	18·4	16·3
Months with Frost		1	2	4	3	3

TABLE 18B.—*Temperate Savanna. Natal*

		Pietermaritzburg.	Estcourt.	Howick.	Ladysmith.
		° ′	° ′	° ′	° ′
Latitude S.		29 35	29 00	29 27	28 33
Longitude E.		30 22	29 53	30 14	29 47
Altitude	ft.	2,272	3,833	3,440	3,284
	m.	692	1,168	1,048	1,000
Rainfall :					
Apr.–Sept.	in.	6·70	4·56	6·31	4·43
	cm.	17·01	11·58	16·02	11·25
Oct.–Mar.	in.	30·24	24·96	27·37	25·31
	cm.	76·80	63·39	69·51	64·28
Rain Days :					
Apr.–Sept.		31	16	28	19
Oct.–Mar.		96	61	91	67
Mean Temp. :					
Apr.–Sept.	°F.	61·2	56·2	56·1	57·8
	°C.	16·2	13·4	13·4	14·3
Oct.–Mar.	°F.	69·8	69·5	65·8	70·6
	°C.	21·0	20·3	18·7	21·4
Mean Min. Temp. :					
Apr.–Sept.	°F.	48·2	42·6	42·0	43·2
	°C.	9·0	5·8	5·5	6·2
Oct.–Mar.	°F.	60·1	57·2	54·7	58·6
	°C.	15·6	14·0	12·6	14·8
Mean Range of Temp. :					
Annual	°F.	40·6	47·0	45·7	50·8
	°C.	22·5	26·1	25·4	28·2
Apr.–Sept.	°F.	36·9	40·4	41·3	44·8
	°C.	20·5	22·4	22·9	24·9
Oct.–Mar.	°F.	25·2	28·5	29·3	30·5
	°C.	14·0	15·8	16·3	16·9
Months with Frost		2	4	4	4

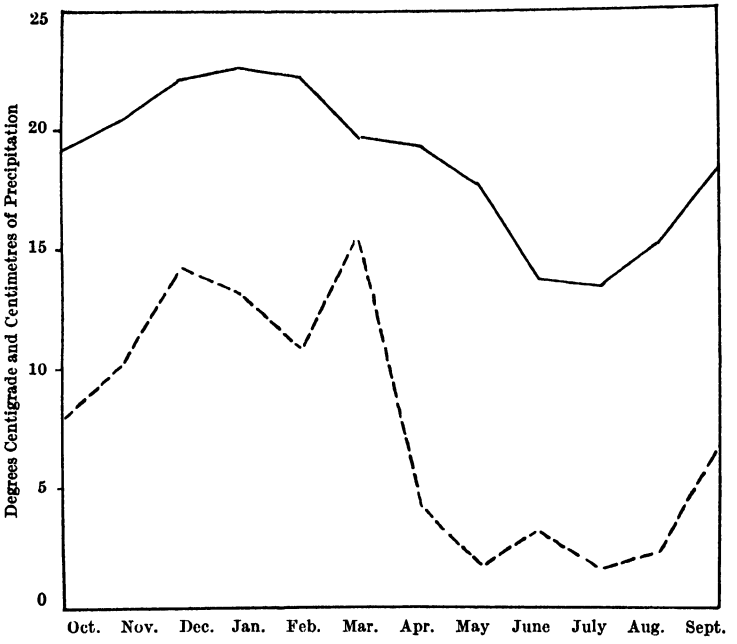


FIG. 9.—Hydrotherm Chart for Temperate Savanna Climate (Pietermaritzburg). Continuous line—mean monthly temperature (°C.); broken line—mean monthly rainfall (cm.).

7. **Low Veld.**—This is a tropical type found in the low-lying country below the escarpment in the Transvaal, Swaziland and parts of northern Natal. It also extends up the valley of the Limpopo. The country is somewhat varied in character, but typical Low Veld does not occur at altitudes over 3,000 feet (915 m.). The climate is hot, with summer rains and dry winter. The total rainfall varies between 15 and 35 inches (38–89 cm.), though most of the country has 20–30 inches (50–76 cm.). About 80 per cent. of the rain falls in summer. The mean temperature in summer is 74°–79° F. (23°–26° C.), and in winter 63°–70° F. (17°–21° C.). Even in winter the mean monthly minimum is not below 54° F. (12° C.). The mean range is 37°–43° F. (20°–24° C.). Frosts only occur in some exposed valleys at the foot of the escarpment, and at the highest levels which show a transition to the following type.

TABLE 19.—*Low Veld*

		Messina.	Komatipoort.	Kaapmuiden.	Barberton.
		° ′	° ′	° ′	° ′
Latitude S. . . .		22 20	25 26	25 32	25 47
Longitude E. . . .		30 03	31 56	31 21	31 03
Altitude . .	ft.	1,950	620	1,342	2,885
	m.	594	189	409	878
Rainfall:					
Apr.–Sept. .	in.	1·19	4·26	3·53	5·77
	cm.	3·02	10·82	8·96	14·65
Oct.–Mar. .	in.	14·32	24·39	23·43	27·18
	cm.	36·37	61·95	59·51	69·03
Rain Days:					
Apr.–Sept. . .		8	17	12	25
Oct.–Mar. . .		24	58	46	79

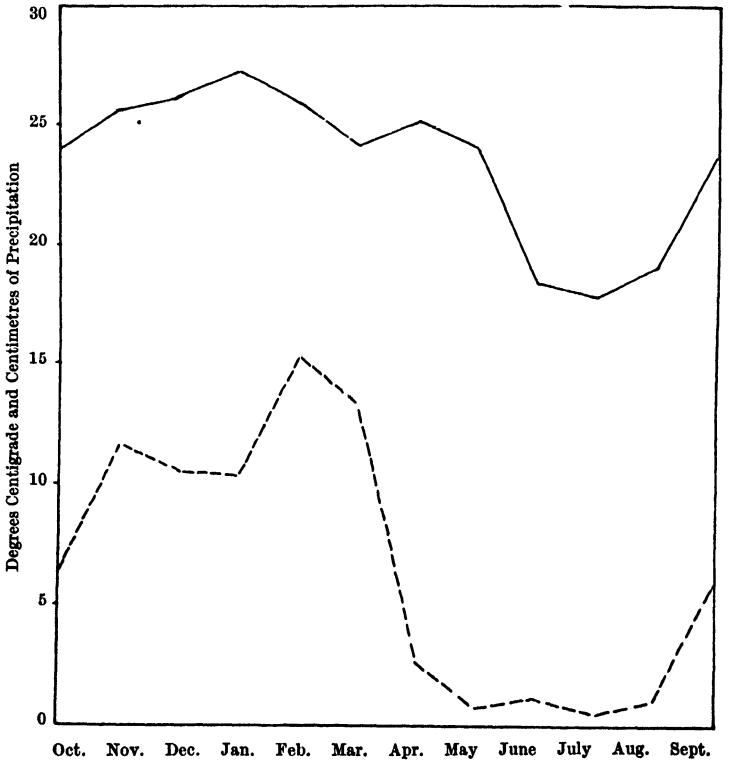


FIG. 10.—Hydrotherm Chart for Low Veld Climate (Komatipoort). Continuous line—mean monthly temperature (°C.); broken line—mean monthly rainfall (cm.).

		Messina.	Komatipoort.	Kaapmuiden.	Barberton.
Mean Temp.:					
Apr.–Sept.	°F.	69·7	70·8	67·5	63·1
	°C.	20·9	21·5	19·7	17·2
Oct.–Mar.	°F.	77·3	78·4	78·3	73·7
	°C.	25·2	25·7	25·5	23·1
Mean Min. Temp.:					
Apr.–Sept.	°F.	56·5	56·8	54·2	55·2
	°C.	13·6	13·8	12·3	12·8
Oct.–Mar.	°F.	64·8	68·2	66·8	62·4
	°C.	18·2	20·0	19·3	16·8
Mean Range of Temp.:					
Annual	°F.	41·8	41·8	43·6	37·4
	°C.	23·2	23·2	24·2	20·7
Apr.–Sept.	°F.	38·3	39·9	37·6	30·8
	°C.	21·2	22·1	20·8	17·1
Oct.–Mar.	°F.	31·6	24·3	28·1	26·3
	°C.	17·5	13·5	15·6	14·6
Months with Frost		0	0	0	0

8. **Bush Veld.**—This occupies the northern part of the plateau, which has a rather broken surface and varied topography. Most of it lies between 3,000–4,500 feet (915–1,370 m.). The rainfall is most often 20–30 inches (50–76 cm.), of which 75–80 per cent. falls in the summer. The mean summer temperature is 70°–73° F. (21°–23° C.), while in winter it is 56°–61° F. (13°–16° C.). The mean minimum in winter may be as low as 39° F. (4° C.). The annual range is often large, 35°–53° F. (19°–29° C.). Frosts occur in winter, but the prevalence and severity vary considerably. Over most of the area severe frosts are rare or unknown.

TABLE 20.—*Bush Veld*

		Nylstroom.	Kopje Alleen.	Pietersburg.	Louis Trichardt.	Rustenberg.
		° ′	° ′	° ′	° ′	° ′
Latitude S.		24 42	24 45	23 54	23 03	25 40
Longitude E.		28 25	28 41	29 28	29 54	27 19
Altitude	ft.	3,735	3,488	4,270	3,120	3,800
	m.	1,138	1,063	1,301	951	1,158
Rainfall:						
Apr.–Sept.	in.	3·25	2·76	2·20	4·20	3·11
	cm.	8·26	7·01	5·58	10·66	7·89
Oct.–Mar.	in.	21·75	23·49	19·44	27·20	22·28
	cm.	55·24	59·66	49·37	68·98	56·59
Rain Days:						
Apr.–Sept.		11	15	11	24	12
Oct.–Mar.		57	63	49	63	61

		Nylstroom.	Kopje Alleen.	Pietersburg.	Louis Trichardt.	Rustenberg.
Mean Temp.:						
Apr.–Sept.	°F.	56·9	60·3	58·3	61·4	55·9
	°C.	13·8	15·7	14·6	16·3	13·2
Oct.–Mar.	°F.	70·9	72·5	70·0	69·4	72·7
	°C.	21·6	21·5	21·1	20·8	22·6
Mean Min. Temp.:						
Apr.–Sept.	°F.	40·0	44·3	41·4	49·4	39·3
	°C.	4·4	6·8	5·2	9·6	4·0
Oct.–Mar.	°F.	57·5	60·5	58·4	60·5	57·5
	°C.	14·1	15·8	14·6	15·8	14·1
Mean Temp. Range:						
Annual	°F.	51·9	48·9	48·1	35·5	53·5
	°C.	28·8	27·1	26·7	19·7	29·7
Apr.–Sept.	°F.	48·1	44·9	45·0	34·7	46·0
	°C.	26·7	24·9	25·0	19·3	25·5
Oct.–Mar.	°F.	31·7	29·7	28·7	22·1	33·0
	°C.	17·6	16·5	15·9	12·3	18·3
Months with Frost		4–5	3	3	1–2	4–5

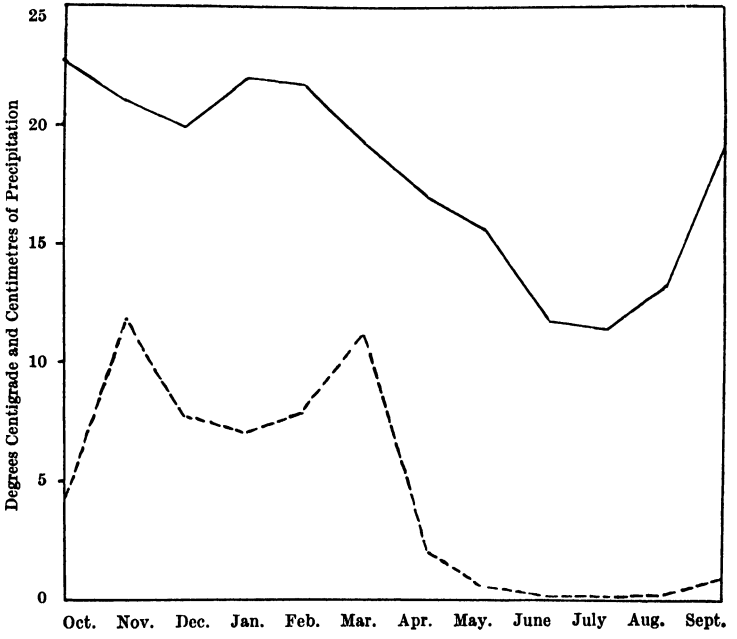


FIG. 11.—Hydrotherm Chart for Bush Veld Climate (Pietersburg). Continuous line—mean monthly temperature (°C.); broken line—mean monthly rainfall (cm.).

9. **Bush Savanna.**—The area of this type is a plateau 3,000–5,000 feet (915–1,525 m.) high, extending from the borders of Bechuanaland to the Orange River. The rainfall is low, 15–18 inches (38–46 cm.), and 80 per cent. of the total falls between November and April. The western and southern limits of the area have rainfalls as low as 10 inches (25 cm.). The winter is dry and such rain as falls then comes in light showers. The mean summer temperature is high, over 71° F. (22° C.), and generally 73°–76° F. (23°–24° C.). In winter the mean is 55°–57° F. (13°–14° C.), with a mean minimum of 38°–42° F. (3·5°–5·5° C.). Frosts occur regularly in the winter months. The annual temperature range is the biggest in the country, 56°–67° F. (31°–37° C.), the winter range being 40°–46° F. (22°–22·5° C.). This type, with its low rainfall and large temperature range, has the most continental climate of all the types.

TABLE 21.—*Bush Savanna*

		Vryburg.	Kimberley.	Postmasburg.	Kuruman.	Prieska.
		° ′	° ′	° ′	° ′	° ′
Latitude S.		26 27	28 44	28 20	27 25	29 39
Longitude E.		24 44	24 46	23 04	23 26	22 45
Altitude	ft.	3,890	4,042	4,328	4,500	3,100
	m.	1,185	1,232	1,319	1,371	945
Rainfall:						
Apr.–Sept.	in.	3·12	3·42	3·19	2·82	2·87
	cm.	7·92	8·68	8·05	7·16	7·28
Oct.–Mar.	in.	16·12	12·44	11·24	13·54	6·76
	cm.	40·94	31·59	28·54	34·39	17·17
Rain Days:						
Apr.–Sept.		10	18	11	11	11
Oct.–Mar.		40	44	23	35	18
Mean Temp.:						
Apr.–Sept.	°F.	57·0	57·7	55·0		57·2
	°C.	13·9	14·2	12·8		14·0
Oct.-Mar.	°F.	73·3	73·4	71·6		76·8
	°C.	22·9	23·0	22·0		24·8
Mean Min. Temp.						
Apr.–Sept.	°F.	41·6	43·7	43·0	38·8	42·5
	°C.	5·3	6·4	6·1	3·7	5·8
Oct.–Mar.	°F.	59·8	59·1	58·2	54·1	61·8
	°C.	15·3	15·0	14·5	12·2	16·5
Mean Temp. Range:						
Annual	°F.	59·6	56·2	58·1	61·8	67·5
	°C.	33·1	31·2	32·2	34·3	37·4
Apr.–Sept.	°F.	46·1	39·9	41·3	46·2	46·2
	°C.	25·6	22·2	22·9	25·6	25·6
Oct.–Mar.	°F.	36·2	37·5	39·7	40·4	45·8
	°C.	20·1	20·8	22·1	22·4	25·4
Months with Frost		4	3	4	4	4

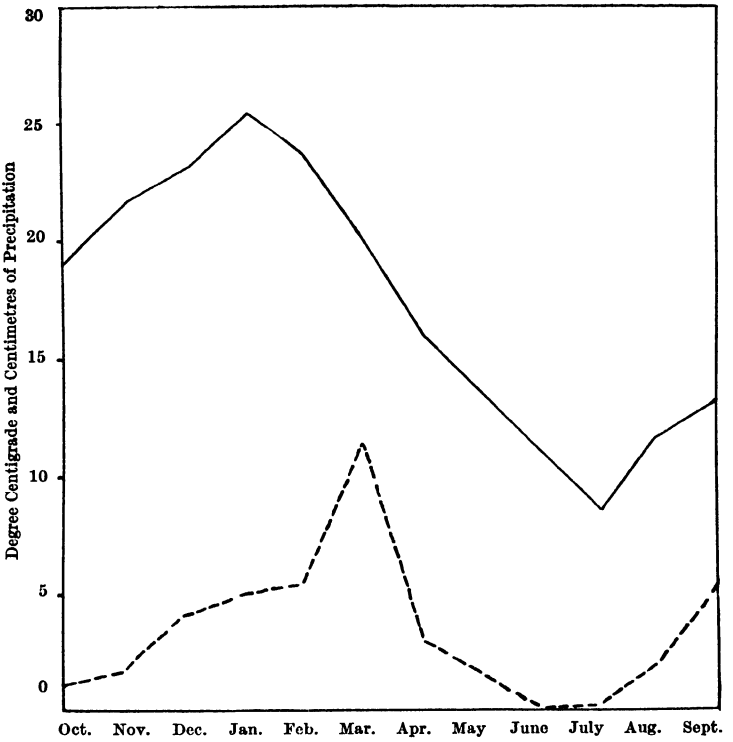


FIG. 12.—Hydrotherm Chart of Bush Savanna Climate (Postmasburg). Continuous line—mean monthly temperature (°C.); broken line—mean monthly rainfall (cm.).

10. **Grassland.**—Grasslands occupy the inland plateau in the southern Transvaal, Orange Free State, parts of Natal and Basutoland. The country is elevated, 3,500 to over 6,000 feet (1,065 to over 1,828 m.). The rainfall averages 20–25 inches (50–63 cm.), but ranges from 16 inches (41 cm.) in the west to over 35 inches (88 cm.) in the eastern highlands. Throughout 75–80 per cent. falls in summer; the winter is dry, rather cold, and very often cloudless. Summer temperatures are 67°–69° F. (19°–20° C.) except in the highlands where they are 61°–63° F. (16°–17° C.). The winter temperature falls to 50°–55° F. (10°–13° C.), with a mean minimum of 39°–41° F. (4°–5° C.). The annual range is 50°–57° F. (28°–32° C.), though only 40° F. (22° C.) in the highlands. Frosts are of regular occurrence in winter and may be quite severe.

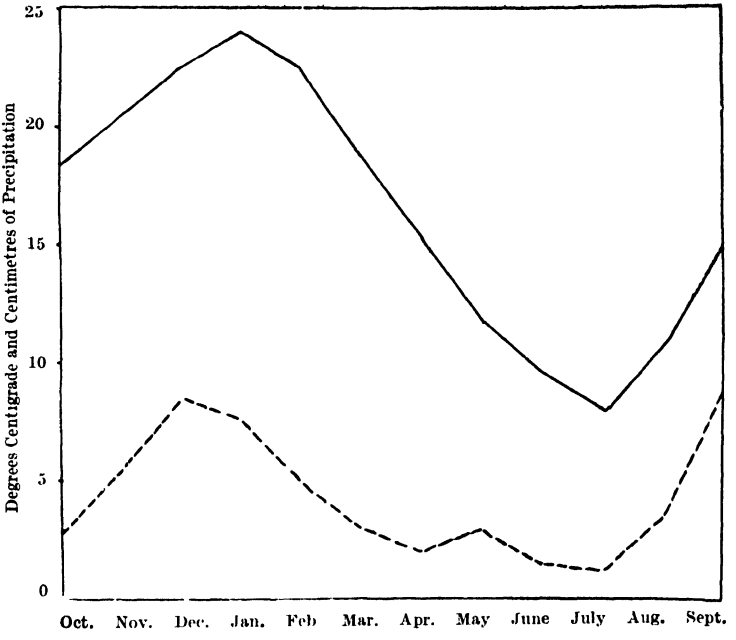


FIG. 13.—Hydrotherm Chart of Grassland Climate (Bloemfontein).

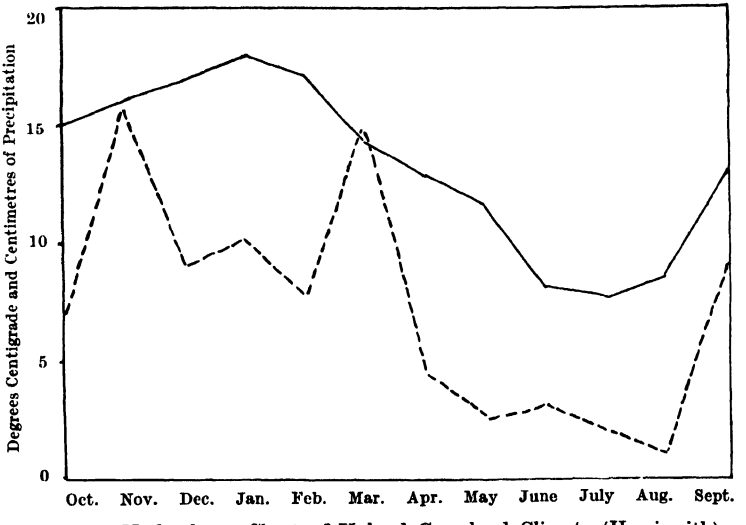


FIG. 14.—Hydrotherm Chart of Upland Grassland Climate (Harrismith).

TABLE 22.—*Grassland*

		Bloemfontein.	Vereeniging.	Lichtenburg.	Ermelo.	Harrismith	Piet Retief.	Dundee.
Latitude S.		29·07	26·40	26·10	26·31	28·16	27·00	28·11
Longitude E.		26·12	27·56	26·10	29·56	29·10	30·48	30·15
Altitude	ft.	4,615	4,718	4,950	5,570	6,100	4,134	4,100
	m.	1,408	1,438	1,508	1,697	1,859	1,260	1,238
Rainfall:								
Apr.–Sept.	in.	4·98	3·92	3·57	3·68	4·32	5·32	5·27
	cm.	12·64	9·95	9·06	9·34	10·97	13·51	13·38
Oct.–Mar.	in.	16·60	23·92	20·48	26·29	21·14	31·70	27·89
	cm.	42·16	60·82	52·01	66·77	54·10	80·51	70·84
Rain Days:								
Apr.–Sept.		19	18	13	17	15	25	16
Oct.–Mar.		46	64	61	66	54	81	62
Mean Temp.:								
Apr.–Sept.	°F.	53·3	54·4	55·7	51·1	50·5	57·6	56·8
	°C.	11·8	12·4	13·1	10·6	10·3	14·2	13·7
Oct.–Mar.	°F.	69·7	69·5	68·7	63·1	61·1	65·9	67·8
	°C.	20·9	20·8	20·3	17·2	16·1	18·8	19·9
Mean Min. Temp.:								
Apr.–Sept.	°F.	40·8	38·7	41·9	40·0	39·4	45·5	42·1
	°C.	4·8	3·7	5·5	4·4	4·1	7·5	5·5
Oct.–Mar.	°F.	57·0	56·4	56·3	51·6	50·5	56·7	55·0
	°C.	13·9	13·5	13·5	10·9	10·3	13·7	12·8
Mean Temp. Range:								
Annual	°F.	55·3	53·0	50·4	40·6	40·0	37·0	46·8
	°C.	30·7	29·4	28·0	22·5	22·2	20·5	26·0
Apr.–Sept.	°F.	39·4	44·1	40·6	35·5	32·8	32·1	40·2
	°C.	21·9	24·5	22·5	19·7	18·2	17·8	22·3
Oct.–Mar.	°F.	37·3	33·8	30·8	27·2	26·9	23·8	21·5
	°C.	20·7	18·7	17·1	15·1	14·9	13·2	11·9
Months with Frost		4	4–5	6	4	5	4	4

Semi-Desert.—Those parts of the country with this vegetation have deficient rainfall, the total varies from less than 5 inches (12 cm.) to a maximum of 18 inches (45 cm.) and is rather irregular both in distribution and amount.

11. **Arid Bush.**—The Arid Bush can be divided into two main divisions, an eastern part, which has rainfall of 8–15 inches (20–38 cm.) most of which falls in summer, and a western part with very low rainfall, 6 inches (15 cm.) or less, largely falling in winter.

The Arid Bush country is from 3,000–5,000 feet (915–1,524 m.) high. This plateau has a dry clear atmosphere and has large temperature changes. The mean temperature in summer is 68°–72° F. (20°–22° C.), but in winter falls to 52°–55° F. (11°–13° C.), with a mean minimum of 35°–44° F. (1·6–6·7° C.). Lower temperatures occur at the higher altitudes and much higher ones in the valleys

in the very dry parts; the lower valley of the Orange River is one of the hottest parts of the whole country.

The annual temperature range is 54°–62° F. (30°–34° C.) in the east, and 62°–64° F. (34°–35° C.) in the north-west. Frosts are of regular occurrence; only the most protected valleys are frost-free.

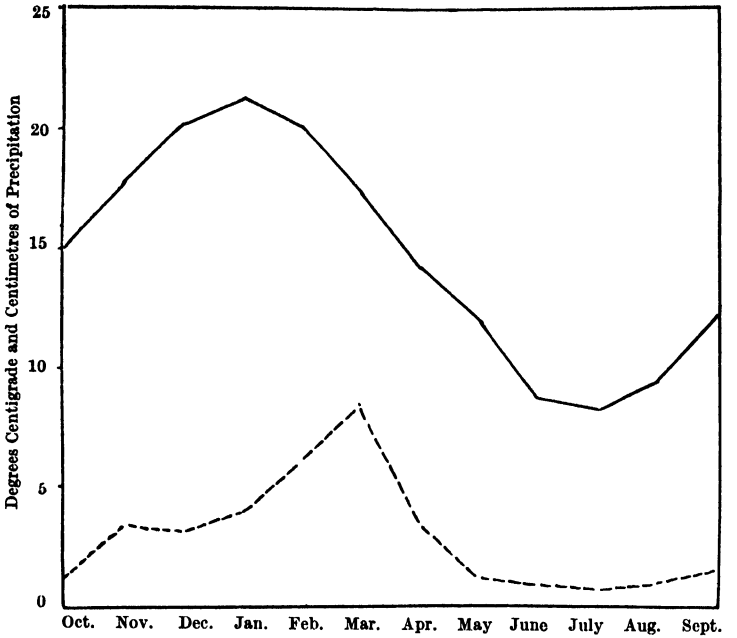


FIG. 15.—Hydrotherm Chart of Arid Bush Climate East (Middelburg, Cape). Continuous line—mean monthly temperature (°C.); broken line—mean monthly rainfall (cm.).

TABLE 23.—*Arid Bush*

		Venterstad.	Carnarvon.	Sutherland.	Van Wyk's Vlei.	Kenhardt.	Goodhouse.
Latitude S. . .		30·47	30·58	32·35	30·21	29·21	28·85
Longitude E. . .		25·47	22·08	20·42	21·49	21·09	18·13
Altitude . .	ft.	4,134	4,060	4,776	3,100	2,704	648
	m.	1,260	1,237	1,455	943	824	197
Rainfall:							
Apr.–Sept. .	in.	5·05	2·72	5·86	2·13	1·76	1·21
	cm.	12·82	6·90	14·88	5·41	4·52	3·08
Oct.–Mar. .	in.	13·56	5·37	3·65	4·52	4·00	1·41
	cm.	34·44	13·63	9·27	11·48	10·16	3·58
Rain Days:							
Apr.–Sept. . .		19	14	25	11	9	12
Oct.–Mar. . .		37	16	15	14	14	9

		Venter-stad.	Carnar-von.	Suther-land.	Van Wyk's Vlei.	Ken-hardt.	Good-house.
Mean Temp.:							
Apr.–Sept.	°F.	51·9	52·5	47·0	55·1	58·7	65·2
	°C.	11·0	11·4	8·3	12·8	14·8	18·4
Oct.–Mar.	°F.	68·6	68·0	61·7	71·8	77·0	83·5
	°C.	20·3	20·5	16·5	22·1	25·0	28·6
Mean Min. Temp.:							
Apr.–Sept.	°F.	38·4	41·0	35·0	41·0	44·1	51·1
	°C.	3·6	5·0	1·6	5·0	6·6	10·5
Oct.–Mar.	°F.	54·3	54·3	45·6	57·0	62·0	68·1
	°C.	12·3	12·3	7·5	13·9	16·6	20·0
Mean Temp. Range:							
Annual	°F.	58·9	62·6	57·0	62·1	64·3	54·9
	°C.	32·7	34·7	31·6	34·5	35·7	30·5
Apr.–Sept.	°F.	43·8	41·9	38·7	42·9	45·0	44·5
	°C.	24·3	23·2	21·5	23·8	25·0	24·7
Oct.–Mar.	°F.	41·2	46·8	49·5	46·1	47·6	48·2
	°C.	23·9	26·0	27·5	25·6	26·4	26·7
Months with Frost		5	5	7	5	4	0

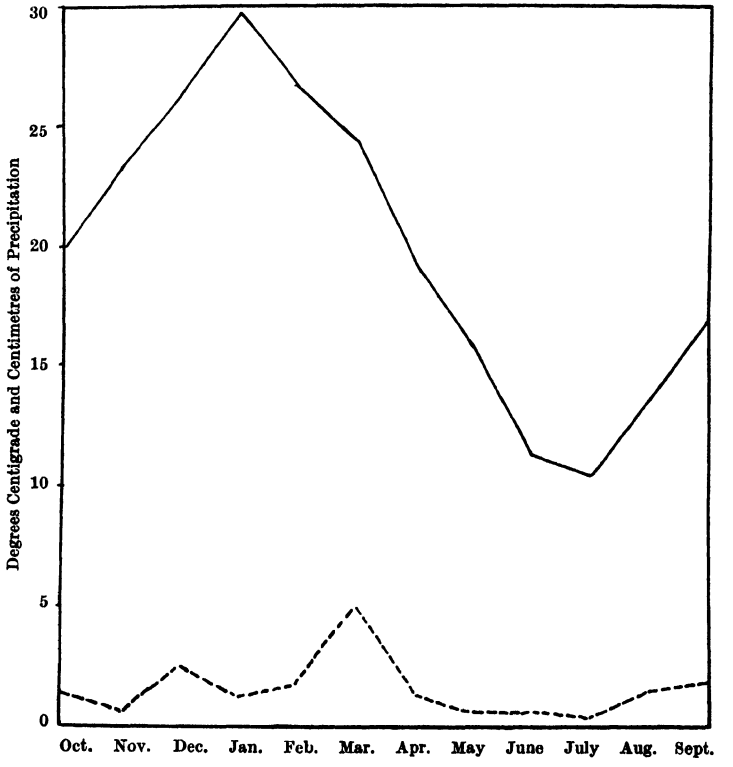


FIG. 16.—Hydrotherm Chart of Arid Bush Climate West (Kenhardt).

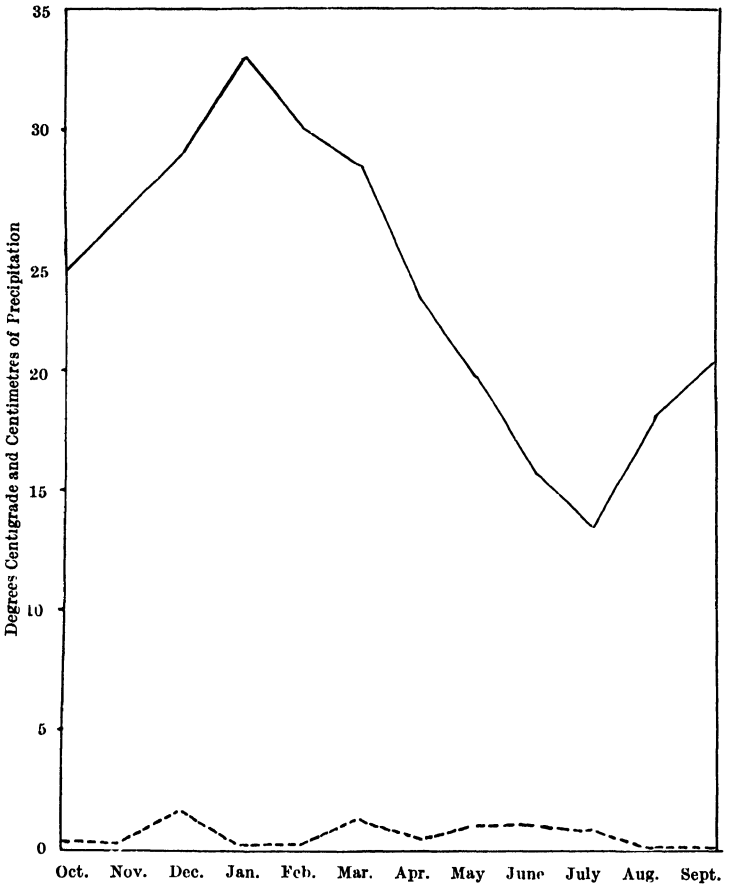


FIG. 17.—Hydrotherm Chart of Arid Bush Climate—Desert (Goodhouse). Continuous line—mean monthly temperature (°C.); broken line—mean monthly rainfall (cm.).

12. **Succulent Bush.**—This vegetation exists at lower altitudes: no part is over 3,000 feet (915 m.), though the whole is over 1,000 feet (300 m.). The rainfall varies from 12 inches (30 cm.) down to less than 5 inches (12·7 cm.). Sixty per cent. falls in summer in the east and about half elsewhere. The rainfall is very unreliable. Summer temperatures are similar to those in the Arid Bush, 69°–70° F. (20°–21° C.), but the winters are less cold. The mean winter

temperature is 51°–55° F. (10·5°–13° C.), with a mean minimum of 40°–46° F. (4·5°–7·8° C.). The annual range is 49°–56° F. (27°–31° C.). Frost is less severe and occurs through a shorter period.

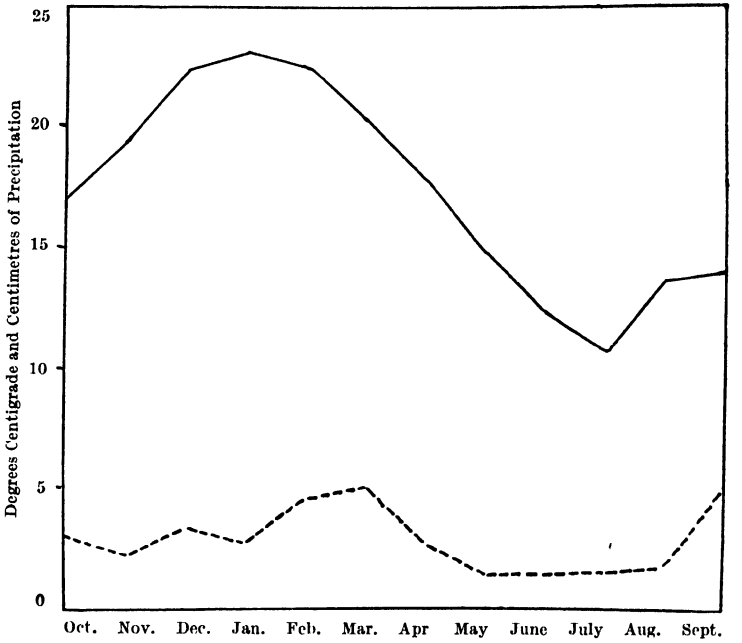


FIG. 18.—Hydrotherm Chart of Succulent Bush Climate East (Graaff Reinet). Continuous line—mean monthly temperature (°C.); broken line—mean monthly rainfall (cm.).

TABLE 24.—*Succulent Bush*

		Laingsburg.	Nelspoort.	Oudtshoorn.	Willowmore.	Graaff Reinet.
Latitude S. . . .		33·12	32·09	33·35	33·17	32·16
Longitude E. . . .		20·52	23·01	22·13	23·30	24·32
Altitude . .	ft.	2,168	3,319	1,090	2,760	2,550
	m.	660	1,010	331	841	777
Rainfall:						
Apr.–Sept. .	in.	2·22	3·11	4·98	3·85	4·81
	cm.	5·63	7·89	12·64	9·77	12·21
Oct.–Mar. .	in.	2·35	6·57	4·65	5·85	9·51
	cm.	5·96	16·68	11·81	14·85	24·15
Rain Days:						
Apr.–Sept. . .		18	15	20	21	18
Oct.–Mar. . .		6	17	15	21	30

		Laings-burg.	Nelspoort.	Oudts-hoorn.	Willowmore.	Graaff Reinet.
Mean Temp.:						
Apr.–Sept.	°F.	53·9	53·7	55·7	51·8	57·0
	°C.	12·1	12·1	13·2	11·0	13·9
Oct.–Mar.	°F.	69·2	68·4	70·0	66·9	69·7
	°C.	20·5	20·2	21·1	19·4	20·9
Mean Min. Temp.:						
Apr.–Sept.	°F.	42·7	41·4	42·6	39·9	46·1
	°C.	5·9	5·2	5·9	4·4	7·8
Oct.–Mar.	°F.	56·0	53·9	54·5	52·8	56·3
	°C.	13·3	12·1	12·5	11·0	13·5
Mean Temp. Range:						
Annual	°F.	51·6	54·0	55·1	56·4	49·4
	°C.	28·6	30·0	30·6	31·3	27·4
Apr.–Sept.	°F.	39·6	38·8	41·4	41·8	36·9
	°C.	22·0	21·5	23·0	23·2	20·5
Oct.–Mar.	°F.	48·0	42·2	41·2	41·0	38·6
	°C.	26·6	23·4	22·8	22·7	21·4
Months with Frost		3–4	4	3	4–5	2

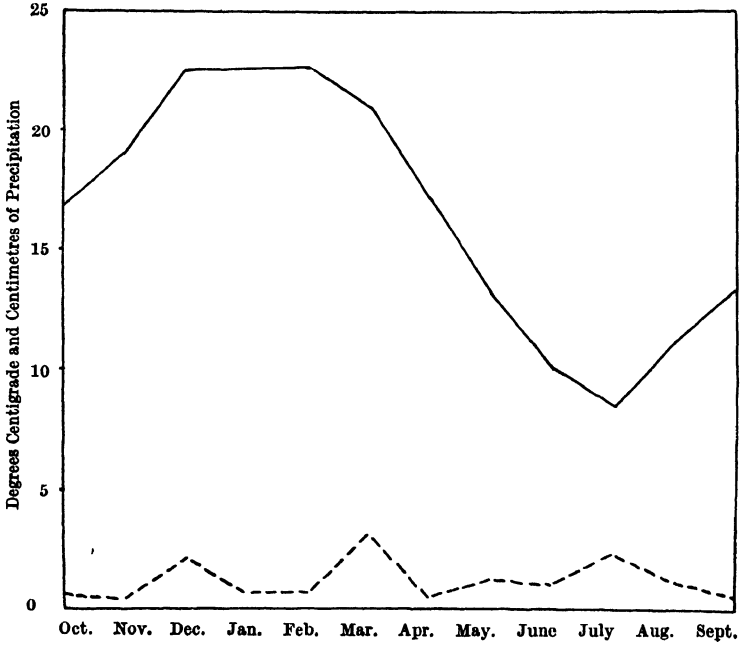


FIG. 19.—Hydrotherm Chart of Succulent Bush Climate West (Laingsburg). Continuous line—mean monthly temperature (°C.); broken line—mean monthly rainfall (cm.).

13. **Coastal Succulent Bush.**—This includes the coast strip from St. Helena Bay northwards to the Orange River. The belt includes low-lying country close to the coast and the seaward slopes of the hills inland. Arid climate extends to a height of 3,500 feet (1,066 m.) in parts, though some of the conditions are modified at these elevations. This belt has a low rainfall, 2–8 inches (5–20 cm.) of which 70–80 per cent. falls in winter. The precipitation in summer is chiefly in the form of light showers and is of little value for the vegetation. The temperature values show a close correlation with proximity to the coast. At the coast the temperatures are low and with small range, whereas further inland the range is greater, and summer temperatures especially are higher. Frosts are unknown on the coastal lowlands but occur inland and at higher altitudes. The conditions at the higher altitudes approach very closely to those obtaining in the Karroo, whereas the frostless coastal lowlands with the smaller temperature range are distinctive.

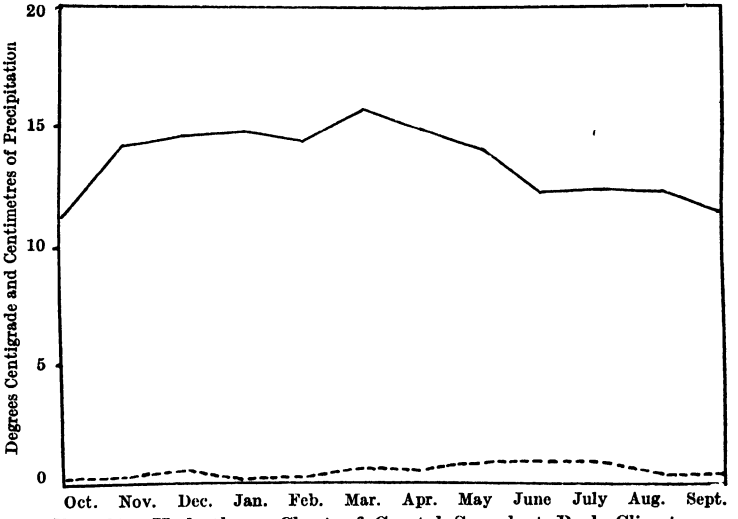


FIG. 20.—Hydrotherm Chart of Coastal Succulent Bush Climate (Port Nolloth).

TABLE 25.—*Coastal Succulent Bush*

		Port Nolloth.	Concordia.	Klaver.	Clanwilliam.
Latitude S. . . .		29·14	29·32	31·47	32·10
Longitude E. . . .		16·55	17·56	18·37	18·85
Altitude . .	ft.	24	3,350	187	245
	m.	7	1,021	57	75

		Port Nolloth.	Concordia.	Klaver	Clanwilliam.
Rainfall :					
Apr.–Sept.	in.	1·91	4·45	6·65	6·94
	cm.	4·85	11·3	16·89	17·62
Oct.–Mar.	in.	0·55	1·95	0·89	1·89
	cm.	1·39	4·95	2·26	4·80
Rain Days :					
Apr.–Sept.		16	22	37	36
Oct.–Mar.		8	8	12	11
Mean Temp. :					
Apr.–Sept.	°F.	54·9	54·2	61·7	58·4
	°C.	12·7	12·3	16·5	14·6
Oct.–Mar.	°F.	57·2	68·6	73·0	72·1
	°C.	13·9	20·3	22·8	22·2
Mean Min. Temp. :					
Apr.–Sept.	°F.	46·9	43·2	40·7	44·7
	°C.	8·2	6·2	4·8	7·0
Oct.–Mar.	°F.	51·1	54·9	58·0	56·2
	°C.	10·6	12·7	14·4	13·4
Mean Temp. Range :					
Annual	°F.	22·2	54·9	49·8	58·8
	°C.	12·3	30·5	27·6	32·6
Apr.–Sept.	°F.	21·6	35·4	33·9	39·9
	°C.	12·0	19·6	18·8	22·1
Oct.–Mar.	°F.	19·4	45·7	45·3	50·0
	°C.	10·7	25·3	25·1	27·7
Months with Frost		0	3	0	2

TABLE 26.—*Summary of Regional Climates*

Type.	Altitude	Rainfall	Percentage of Rain in Summer.	Mean Temperature. Summer.	Winter	Mean Temp. Range.	Frosts.
Sclerophyll	0–2,500 0–762	16–50 40–127	20–40	62–69 17 20	50–58 10–14	23–39–55 13–21–31	Inland only.
Temp forest	0–2,000 0–610	35–45 88–114	50	63–64 17–18	54–57 12–14	27–31 15–17	0
Warm temp. forest	0–1,250 0–380	(15–)48–50 (38–)120–127	60	68–70 20–21	59–65 15–18	23–43 13–23	0
Montane forest	Over 4,500 ,, 1,370	Over 59 ,, 150	80–85	62–63 16·5–17	54–55 12–12 5	30–34 16 5–18 5	
Subtrop. forest	0–1,000 0–300	40–50 102–127	60–70	Over 70 ,, 21	Over 64 ,, 18	27–33 15–18	0
Temp. savanna	1,500–4,200 450–1,280	20–40 50–100	75–80	65–70 18–21	54–59 12–15	40–52 22–28·5	Winter months.
Low veld	500–3,000 152–915	15–35 38–89	80	74–79 23–26	63–70 17–21	37–43 20–23	0
Bush veld	3,000–4,500 915–1,370	20–30 50–76	75–80	70–73 21–23	56–61 13–16	35–53 19–29	Mid-winter
Bush savanna	3,000–5,000 915–1,525	15–18 38–46	80	Over 71 ,, 22	55–57 13–14	56–67 31–37	Mid-winter.
Grassland	3,500–6,000 1,065–1,828	20–25 50–63	75–80	61–69 16–20·5	51–55 10 5–13	50–57 28–32	Winter
Grassland (montane)	Over 6,000 ,, 1,828	Over 25 ,, 63	75–80	61–63 16–17	50–51 10–10·5	40 22·5	Winter.
Arid bush	3,000–5,000 915–1,525	Under 15 ,, 38	40–70	68–72 20–22	52–55 11–13	54–62 30–34	Winter.
Succulent bush	1,000–3,000 300–915	2–12 5–30	50–60	69–70 20–21	51–55 10 5–13	49–56 27–31	Mid-Winter.
Coastal succulent bush	0–3,000 0–915	2–8 5–20	20–30	57–73 14–23	54–61 12–16	22–58 12–32	Inland only

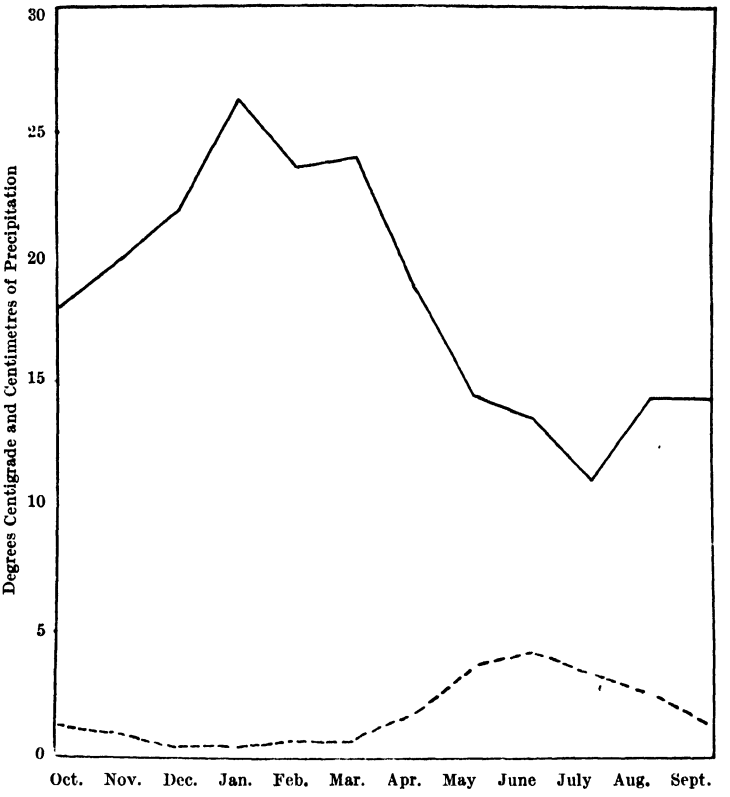


FIG. 21.—Hydrotherm Chart of Coastal Succulent Bush, Inland Climate (Clanwilliam).

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CHAPTER III

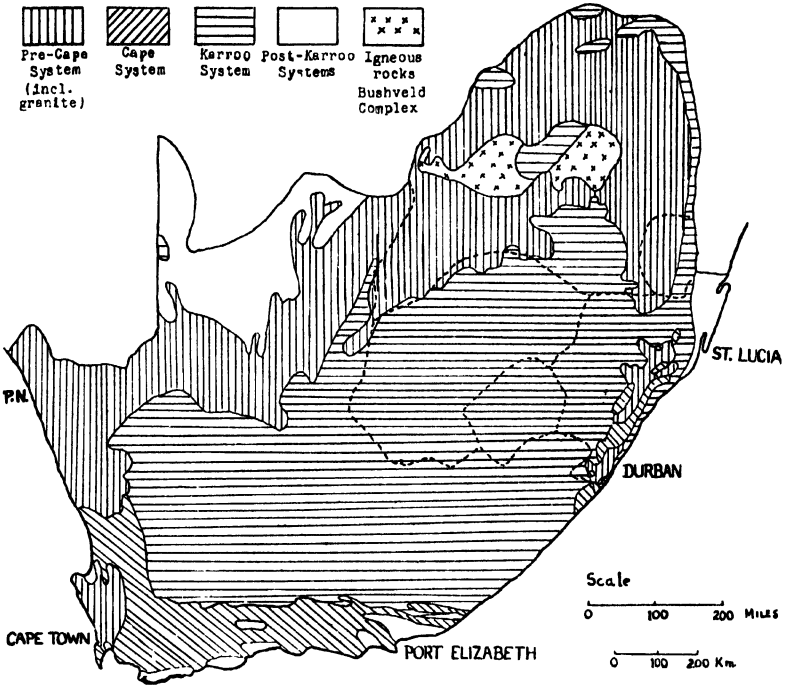
GEOLOGY AND SOILS

GEOLOGY

THE geological structure of the country and the relations of the stratified and other rocks have now been worked out more or less fully, and the present account will be limited to the merest outline. Geologically, South Africa is a very old continental area; submergence of the interior under the sea does not appear to have occurred since very early palæozoic times. The vast accumulation of strata that form a very large proportion of the present surface, and which represent the deposits of the later palæozoic and mesozoic times, are not of marine origin, but were laid down under fresh water or continental lagoon conditions. Fossiliferous marine deposits are confined to the coastal belt. The stability of the country as a continent is shown by the fact that more than half the area is made up of horizontal or nearly horizontal sediments of upper palæozoic or mesozoic age. Post-palæozoic foldings are almost confined to the southern part of the Cape Province.

In the most general terms three geological regions can be recognised, the basement of ancient formations principally found in the north, the widespread and nearly horizontal Karroo System, and the smaller area in the south occupied by the Cape System. A fourth region, which is occupied by the more recent Kalahari System, of continental origin, mostly lies beyond the borders of the Union, but covers the northern parts of Gordonia and the Kuruman district. The ancient basement of pre-Cambrian and early palæozoic sediments and volcanic rocks, along with extensive intrusive granite, forms extensive outcrops in the Transvaal, the Cape Province north of the Orange River, and in the north-west Cape. It also extends northwards into South-West Africa and Rhodesia. A lengthy succession is represented by these ancient formations. The Karroo System occupies the great plateau extending from the Vaal River valley to the southern coastal belt. It

includes the whole of the Orange Free State and much of the Cape Province. The System extends on the east beyond the escarpment to the east coast. The Cape System, largely if not entirely of Devonian age, occupies much of the coast belt in the south and south-west. It also appears in Natal. In the southern Cape Province the rocks are strongly folded about axes roughly parallel to



Map 9.—Geological Map of South Africa (generalised from a map by A. W. Rogers, 1933).

the coast and give rise to mountain ranges of rugged character. This forms the so-called Cape Folded Belt. Igneous or volcanic rocks are found over many parts of the country.

The basement or pre-Cape System, which represents the old continental surface on which more recent systems have been deposited, forms in the Union a belt running round the margin of the Great Kalahari area. On the west these rocks appear at the surface from

Van Rhynsdorp in Namaqualand northwards; they extend eastwards and north-eastwards through Bushmanland and the Orange River valley to Griqualand West and cover the central and northern Transvaal. The River Vaal from Parys to its junction with the Orange River, and the latter river as far as Prieska roughly follow the southern boundary of the outcrop. The pre-Cape formation is not by any means uniform, either in the characters of the rocks or in their age, and various divisions have been recognised. Large areas are occupied by ancient granite and gneiss, notably in Namaqualand, Bushmanland, the northern and north-eastern parts of the Transvaal, and in Swaziland. This granite extends northwards over much of Rhodesia. In distinction from other intrusions it is referred to as Old Granite.

The sediments and associated volcanic rocks which are of greater age than the Cape System are almost entirely without fossils. They lie upon the Old Granite and associated schists, but are themselves penetrated by younger intrusions in certain areas, notably in the central Transvaal and in the south-west Cape. The most remarkable of these younger intrusive formations is the well-known Bushveld Igneous Complex, which is perhaps the most important formation geologically in the Transvaal. The igneous rocks of this Complex form a great shallow oval basin about 200 miles from east to west, overlying beds which dip inwards beneath the Complex and form an encircling girdle of mountains. The cake of igneous rocks appears to be several miles thick.

The Cape System which follows next in the series is completely separated geographically from the older rocks, except in the south-west Cape. The Cape Rocks are confined to the coastal region in the south and south-west Cape, and to a strip in Natal running from Port St. Johns northward to Zululand. The main area extends from the southern border of Namaqualand southwards and eastwards to a point midway between Port Alfred and East London. The inland boundary is marked by the mountain ranges separating the coastal belt from the inland plateau of the Karroo. The Cape Rocks lie unconformably on the weathered surface of the older rocks and the associated younger granite, but themselves form a conformable series.

These Cape Rocks have been subjected to much folding and faulting, which, combined with denudation, has produced a very

characteristic type of landscape. The hard sandstones form steep-sided mountain ranges, very different in general appearance from the smoothly rounded hills formed from the older rocks. The softer rocks have been denuded and now occupy the lower ground. The main lines of folding run more or less parallel to the coast, and the present mountain ranges represent portions of denuded anticlines. In addition, foldings or crumplings in other directions have also taken place and in parts the rocks are violently disturbed.

The Karroo System covers about two-thirds of the total area of the Union. The area occupied extends from the landward margin of the Cape System and covers a large portion of the Cape Province, almost the whole of the Orange Free State, the south-eastern Transvaal, and most of Natal. Southwards from the pre-Cape Rocks the whole of the interior plateau is made up of rocks belonging to this system.

The Karroo Rocks are regarded as having been deposited in a basin and, except for local disturbances at the margins, the beds dip inwards at a low angle. The present surface occupied by these rocks is not a basin, but the basin origin is definitely indicated by the succession of the rocks. The margins of successive beds from below upwards surround those above in successively smaller concentric rings. The present surface forms an elevated plateau, with the highest parts in the east and descending towards the west, though it is broken by various ridges and steps. The rocks forming this huge area make a regular conformable series from base to top. The strata are all horizontal, or at most inclined at a low angle. It is only along the south-west border of this large area that folding has occurred. Here the rocks are folded and crumpled very decidedly in places. Some outcrops show beds in an almost vertical position. These foldings appear to be part of the same series of earth movements that produced the folds in the underlying Cape Rocks. In the Karroo Rocks the foldings only affect the lowest strata which are in immediate proximity to the older ones. At the south and south-west margins of this area the Karroo System follows conformably on the top of the Cape System. Elsewhere the System lies unconformably on the older ones.

The Karroo System extends from the Carboniferous period at its base to the Jurassic at the top. The base was deposited under glacial conditions. Extensive coal seams occur in the Transvaal and

in Natal in the lower strata and small ones of more recent date in the Cape. The top of the Karroo System is represented by very extensive basaltic lavas, with occasional beds of tuff or ash, which form the highest parts of Natal and Basutoland. On the escarpment these lavas, which are dark-coloured, form a striking contrast to the pale sandstone underlying them. Lavas of this kind also stretch for hundreds of miles along the Lebombo Mountains, which separate the low grounds of Swaziland and the north-eastern Transvaal from the coastal plain. Throughout the area of the Karroo System there occur evidences of volcanic activities, though of a quite different kind and of later date. Intrusions of dolerite in the form of dykes or sills are very common. Some of these are extensive, others quite small. These dolerite intrusions are found penetrating all the Karroo Rocks and are absent only in the extreme south and south-west of the area. The rocks of the Karroo System have been very much denuded since their deposition. The strata are horizontal, or nearly so, and denudation has resulted in the formation of a surface broken by endless hills or koppies of varying size. Very often these projections are capped by portions of dolerite sills, or less commonly by harder sandstone beds. The sill-capped hills are table-topped or conical, and often exceedingly regular and symmetrical in form. Dolerite dykes give rise to less regular elevations. These often have the form of lines of dolerite boulders.

Rocks of the Karroo System are not confined to this one large area; outliers and smaller areas occur in various places. Some of these almost certainly represent portions of the main area whose continuity has been lost by denudation. Such outliers are to be found in the lower valley of the Orange River, in South-West Africa, and in Gordonia; others occur between the Vaal River and Mafeking. In Natal a strip of Karroo Rocks, separated from the main area by an outcrop of Cape Rocks, occurs along the coast from Durban northwards. This strip has become separated by denudation following folding. In the northern parts of the Transvaal there are a number of patches of Karroo Rocks which probably belong to a separate northern area of deposition which was divided from the main South African region by the ridge of the pre-Cape Rocks. A small outlier occurs in the south-west Cape near Robertson on the coastal side of the range of mountains formed of Cape Rocks. This patch owes its origin to faulting and subsequent erosion.

Since the close of the Karroo period, that is since Jurassic times, southern Africa has been a stable area. More recent deposits are either of land origin or are confined to the coastal belt and occupy positions very little raised above the present sea-level. Rocks of Cretaceous age occur as patches at or near the coasts in the Cape and in Zululand.

By far the most extensive and, for effect on vegetation, much the most important of the post-Karroo deposits is the so-called Kalahari Sand. This is a deposit, in places of great thickness, which is largely unconsolidated but covers an enormous area. It extends over the the greatest part of the Bechuanaland Protectorate and southwards into the Cape Province in the Gordonia district and north and west of Kuruman. In other directions this sand extends into South-West Africa, Southern Rhodesia, and across the Zambesi River to Barotseland in Northern Rhodesia and into Angola. Over this immense area the surface is occupied by a sand generally red in colour. It may be quite loose or it may have deposits of calcareous tufa at the surface or a short distance below. In places there is a more or less solid deposit of marl or sand bound by lime; locally silicified patches or "silcretes" are found.

This Kalahari Sand occupies an immense plain, much of which has internal drainage. The northern parts are well supplied by rivers which merge into swamps, but the central and southern parts are practically without surface water and hence are commonly referred to as the Great Kalahari Desert. Within the area of the Kalahari Sand outcrops of older rock occur here and there. Those within the Cape Province are small areas of pre-Cape Rocks. The sand itself is a deposit formed under desert conditions and generally considered as belonging to the later Tertiary Period. Other Tertiary or more recent deposits occur on the coast belts. Quite extensive areas along the west coast, between Table Bay and the Orange River, are covered by unconsolidated sands of recent origin. Similar deposits occur on the east coast from Zululand northwards.

Solid rock of Tertiary age is found in places on the south coast. Limestones occur near Cape Agulhas and elsewhere, and silicious beds are not infrequent. None of these is very extensive or important in the delimitation of the vegetation.

SOILS

While the geological sequence and nature of the rocks determine the topographic and other features of the country, the factor of first importance in the determination of plant distribution is the soil. A soil is essentially composed of broken rock, but in the course of its formation large changes occur which may render its structure and composition very different from those of the original rock. The final result is a soil whose characters are largely determined by the climate and by the length of time during which it has been exposed to the agents of change. In other words, just as vegetation undergoes a gradual process of development primarily controlled by climate, so a modification and rearrangement of the soil goes on that culminates in a condition determined by the characters of the local climate and vegetation. A soil that has become modified to the extent possible under the local conditions is said to be mature. The series of changes in the soil culminating in maturity do not at all necessarily follow the phases of development of the vegetation. The time factors are different. Quite stable climax vegetation can be found on immature soils. In any country it is obvious that a large proportion of the soils will be immature or in a state of degradation owing to erosion.

The soils of the Union of South Africa have been investigated to a considerable extent, but almost entirely from an agricultural standpoint. The chemical composition, physical features, fertility and responses to manuring have been investigated in a number of areas. Investigations have also been undertaken on the relationships of soil to parent rocks. While a large volume of knowledge has been collected it consists of a great mass of detail, and very little indeed has been done on the determination of soil types or on the common features of soils over wide areas of country. The investigations that have been carried out tend rather to emphasise points of difference than to bring out similarities of development. Over most of the country there is no information on soil profiles or other essential morphological features.

The first attempt at a classification of the soils from a developmental standpoint was made by Marbut in 1923. He recognised a number of soil types some of which he correlated with types recognised in the Northern Hemisphere. The main types were: "Brown Soils" of the Cape, formed under winter rainfall; "Brown Desert

Soils," which were mapped as a belt up the centre of the country; "Tschernozem Soils" and "Light Coloured Soils of the Tschernozem Group," found in the summer rainfall parts, the former in the wetter regions; "Prairie Soils," characteristic of the higher regions of the Transvaal, Orange Free State and Basutoland; and "Natal Red Loams," which are red soils found on the eastern coastal belt and in parts of the northern Transvaal.

Marbut constructed a soil map, but on the data he had at his command this must be regarded as really a climatic map, showing the soil type that might be expected rather than any actual distribution of soils. Marbut's classification has not met with any general acceptance among soil workers in South Africa, but so far no alternative scheme has been advanced.

In view of the lack of knowledge of structure and profile it is, perhaps, inadvisable to attempt any close correlation with soil types in the Northern Hemisphere. In the succeeding descriptions general features alone are mentioned. Much work is needed before the real identity of the various types can be regarded as settled.

Throughout South Africa limestones are rare; this absence is correlated with the ancient continental character of the country. Limestones are quite absent in the enormous area covered by the rocks of the Karroo System. The only ones of more than local occurrence are the dolomites of the Transvaal System found in parts of the Transvaal and in Griqualand West. There is also a very general deficiency in lime-containing minerals. The vast majority of the soils here fall into the non-lime accumulating group, but the lack of lime accumulation is due to an absence of the necessary materials and not to leaching. Even in the arid and semi-arid regions the soils are generally quite without accumulated lime.

Another feature of lesser importance is the absence of earthworms. These do occur but are either of local occurrence or are absent from the superficial layers. No other organisms play the part taken by earthworms in mixing materials.

A very large part of the country is covered by soils in an immature state. The great prevalence of very shallow soils in which the solid rock is close to the surface, and of very stony soils, is evidence of this. This abundance of immature soils and their close connection with topography and geological structure has undoubtedly influenced the outlook in soil study, and tended to an emphasis on the

correlation of soil and its origin rather than on the climatic characters.

In South African soils the colour bears a close relation to the origin: in areas of uniform climate passage from one underlying rock to another is often marked by a change in the colour of the soil. The essential characters of structure and profile may be the same but the colour contrast quite striking. In this account colour is regarded as subsidiary in importance.

No attempt is here made to present a complete picture or classification of the soil types of the country. Information from many parts is very scanty; even in the well studied regions knowledge of the profile and development is very scarce, and the most that can be attempted is to write a series of notes on the salient characters of the soils of the various vegetation types in the hope that they may be useful in drawing attention to an important and so far neglected study.

Sclerophyll and Temperate Forest.—These are the types occurring in the winter rainfall area. The region is one of very uneven surface. Even the relatively level country of the coastal belt is dissected by river channels. The region falls into two parts: one characterised by heavy rainfall without a distinct dry period on the mountains and in the forest belt; the other more extensive, with a dry summer and a warmer climate. In the first division the soil type approximates closely to the well-known podsol type. The characteristic features are a dark or black surface layer with much humus which overlies a stratum of bleached soil; below this at 1 to 3 feet (30 to 90 cm.) from the surface a darker layer, sometimes with definite ironstone nodules, is formed. The surface layers have larger quantities of humus than the great majority of soils in this country. The reaction is typically acid, *p*H 4·5–5. Most commonly the humus is without preserved structure, though peat-like layers that contain structural plant remains do occur occasionally. In some of these soils, and especially in the forest soils, the humus layer is comparatively shallow and superficial, 2–8 inches (5–20 cm.) in thickness, while in others, and notably in those with poor drainage, the dark or black layer may extend to 2–3 feet (60–90 cm.) in depth. The iron concretionary layer is best developed in the forest soils. In many of the mountain soils it is represented merely by a darker band or is quite absent. The podsol-like soils are most characteristically

developed from quartzites or quartzitic rocks. Those derived from other rocks found in the forest area have a smaller amount of surface humus and a less bleached layer below.

Rather different soils are developed in the parts with more definitely winter rainfall and dry summer: these are the "Brown Soils of the Cape" of Marbut's classification. They vary considerably in colour, though brown and red-brown are the most common. Some are pale brown or even grey. The distinct surface humus layer is lacking. The surface layer, 4–6 inches in depth, passes gradually into a layer of paler colour below. Ironstone concretions are generally present at a depth of 8–15 inches. When these concretions form a continuous layer of any thickness they are dug and utilised as a source of road material. In the more sandy soils the colour is paler and the concretionary layer deeper and sometimes absent. In some of the coastal sands on the Cape Flats and along the west coast lime concretions replace the commoner iron ones. The lime is derived from shell *débris* in the sand. This layer of concretionary lime is made use of as a source of lime in some places. The surface is neutral or slightly acid, except in the lime-forming sands, which are more or less alkaline.

Montane Forest.—The mature soils here are deep, uniform to a considerable depth, and red or red-brown in colour. There is no definite humus layer, and most often no discoloration of the upper soil. The first 6–12 inches (15–30 cm.) are typically rather fine-grained, the lower part coarser grained.

Warm Temperate Forest and Temperate Savanna.—These occupy a region of temperate climate with summer rainfall. The country is mostly a dissected peneplain rising inland to mountain slopes. The mature soils of the Savanna country vary in colour: in the south-eastern Cape the prevailing tint is brown, but the tone ranges from chocolate to yellow-brown. Some black soils are found but are rather local in occurrence. The soil typically has a uniform, often compact, surface layer, 8–15 inches (20–38 cm.) in thickness. This layer often has a high percentage of clay and is relatively impermeable. There is no distinct humus layer. The surface stratum overlies a looser and generally paler stratum of variable thickness. The junction between the two may be sharp or gradual. In most of the soils concretions are absent, but calcareous nodules have been described in a few cases as occurring in the looser layer about 3 feet

(90 cm.) from the surface (*cf.* Bews, 1912, Plate XX). In the drier and warmer regions bright red soils are formed, though apart from the colour their characters are very similar. Examples are common at the lower levels in Natal and also in the Uitenhage basin: these red soils are a part of Marbut's "Natal Loams."

Grassland.—The grasslands which occupy the high plateau in the southern parts of the Transvaal, Orange Free State, Basutoland and the higher levels in Natal, cover an area much less broken in surface than is the case with the types described above. The more uniform surface has allowed a greater proportion of the soils to reach the mature condition.

The Grassland area is a large one, with a not inconsiderable range of climate between the eastern and western limits. These differences in climate cause reactions in the soil characteristics. In the central and eastern parts of the area, where the rainfall is greater, the mature soil is deep, porous, and rather uniform to a depth of 2–4 feet (60–120 cm.), or even more. There is considerable variation in colour; while brown tints are the commonest, they range from chocolate to yellow, with also red tones in places, from deep red to bright red-brown. The surface layers are darker and discoloured by humus but pass gradually into the lower strata. There may be a sharp distinction in colour between the surface and lower layers, but otherwise the transition from one to the other is gradual. For example, in one case the uppermost layer was a deep chocolate stratum about 2 feet (60 cm.) thick: this showed a lessening in intensity of colour from above downwards. At 2 feet there was a gravel layer 2 inches thick above a bright yellow subsoil of considerable depth.

Concretionary layers are not by any means of general occurrence. In parts iron nodules are found, occasionally forming a continuous band; calcareous nodules are rare. On the other hand, a band of small gravel-like stones is a very common feature at a depth of 2–3 feet (60–90 cm.) from the surface. Though the surface soil is generally dark-coloured the amount of humus contained in it is not large; the loss on ignition varies from 8 to 27 per cent. The surface layer is permeable and granular, and the soils are generally classed as loams though actually they often contain quite a high percentage of clay. Even in soils derived from sandstones the clay fraction in the upper layers is as high as 25 per cent. These Grassland soils have

a distinct deficiency in lime and carbonates, but are not excessively leached: the percentage of soluble materials, alkali, etc., is not especially low.

The soils in the northern and north-eastern parts of the Grassland are predominantly red in colour; some are a brilliant vermilion, though less vivid tints are commoner. In the Montane regions with heavy rainfall the soils have a very dark, often black, surface layer over a variously coloured, though very often red, subsoil. Iron nodules are formed between soil and subsoil.

As compared with the soils of the Temperate Savanna which occur at lower altitudes, these Grassland soils have a less compacted and much more porous surface layer, which also passes gradually and not abruptly into the subsoil.

The Grassland soils include the types termed by Marbut "Transvaal Prairie Soils" and "Light Coloured Soils of the Tschernozem Group." At present there does not seem sufficient evidence to justify a separation into two groups. The soils at the higher levels, though much darker in colour, show the same major characteristics as the others. The general poverty in lime of all these soils renders a close association with the Tschernozem group rather doubtful unless the definition is widened a great deal. There are, however, some soils, which are rather local in occurrence, which appear very similar to the typical Tschernozem type as recognised in Europe. These are the localised "Black Turf Soils" or "Black Cotton Soils," which are also known as "Black Vlei Soils" in Southern Rhodesia. They are dark, often quite black, soils which have a relatively high lime content, and most often show a calcareous concretionary layer in the subsoil. The soils are fine-grained and have a high water-holding capacity. The surface layers contain 35–45 per cent. of clay, but, although black, do not contain large amounts of humus. The loss on ignition is only 7–10 per cent.

These soils are restricted to areas underlaid by basic igneous rocks. Their special characteristics apparently depend on differences in the character and composition of the parent material. Around them, under the same conditions of climate, are soils of the ordinary Grassland type which are derived from less basic rocks. Both represent a climatic development and seem merely variations of one type. There is no reason for associating these black soils with especially wet conditions. Black soils of marsh origin commonly

occur in depressions and river valleys, but do not show the characters of the "Black Turf Soil." It is to the valley soils that the term "Vlei Soil" should be restricted.

In the western part of the Grassland region, where the rainfall is less, soils of a slightly different type occur: these are paler in colour and without any darkened surface layer. Such soils are red, yellow, light brown, or less often grey, but very rarely dark. The surface layer is more compacted and less porous than in the soils of regions with more adequate rainfall. These paler soils often appear uniform to a considerable depth, though bands of concretions or of denser soil are not uncommon at depths of 12–18 inches. Calcareous concretions have not been described. The paler soils are a development in response to drier conditions and less dense vegetation. All stages of transition from one type to the other can be found where there are transitional kinds of climate. The paler soils of the drier belt have been classed as "Chestnut Brown Soils" or "Chestnut Earths," largely on account of the climatic similarities to regions where such types occur in the Northern Hemisphere. The soils here are generally paler in colour and less distinctly stratified than the typical "Chestnut" soils of the north. Soils of this drier type extend beyond the limits of Grassland vegetation and occur in parts of the region of the Bush Savanna in the Lower Vaal valley.

Low Veld.—This region, with its rather dry but tropical climate, has soils which vary considerably in colour and in depth. The mature soil is characteristically deep, and usually very uniform a long way down from the surface. Brown, red and chocolate colours are especially common, though some are bright red or orange. Grey, clay-like soils are common at the higher levels just below the escarpment. The soils derived from the granite in the northernmost parts are red or pink. Very little information is obtainable on the details of structure of these soils.

Bush Veld.—So far as they have been investigated the soils of the Bush Veld region in the northern Transvaal have features similar in many respects to those of the Grassland. The topography is much diversified and a very large proportion of the area bears soils that are evidently immature. In the more mature soils the colour seems rather closely related to the nature of the parent material. Red and reddish colours are the commonest, though brown, chocolate and dark soils also occur. The red soils are generally less fertile than the

others. As compared with the Grassland soils, those of this type are more uniform, have a lesser distinction between soil and subsoil, and are rather more compacted and less porous. In the grey and black soils of some of the drier plateau regions a clay-like surface, underlaid by calcareous concretions at a depth of about 18 inches, is formed. The concretions may be of sufficient quantity to justify their being worked locally as a source of lime.

Some of the soils derived from the magnesian limestone deserve mention, especially as they differ from soils of the same origin in Griqualand West. These soils are red or reddish and thoroughly leached. The soils are generally stony, with numerous lumps and fragments of chert. They give no effervescence with acid. Such soils are comparable with the " Terra rossa " of southern Europe.

Bush Savanna.—This region is characterised by a low rainfall and high temperature in summer. It has a characteristic vegetation and some characteristic soil types. The soils show differences in accordance with their origins. The region falls into two divisions, a hilly part built of older rocks, with a level plateau of magnesian limestone, and a lower part largely covered by Kalahari sand. In the hilly region the soils are generally immature, shallow and stony. On the level plateau of magnesian limestone pale-coloured soils are formed which have bands of consolidated lime near the surface. These bands may be continuous rock-like layers or gravel-like beds: in either case the lime bed is often exposed at the surface by wind erosion.

The Kalahari sand forms a bright red sandy soil, most often loose and uniform to considerable depths. Layers of re-deposited lime, either solid or as marl bands, are of very common occurrence at depths varying from a few inches to several feet from the surface. The soils have no humus layer, and apart from the lime beds are uniformly coloured. The characters of these Kalahari sand soils depend on the degree of stability and the depth and completeness of the lime bands. Wind erosion and re-deposition are of common occurrence, and the concretionary layers may be exposed at the surface or buried to considerable depths. In the latter case a duplication may result. As compared with most of the soils of the country the most striking character of these soils is the general presence near the surface of the re-deposited lime layers.

Arid Regions.—For the present purpose the arid regions may be regarded as a unit, though the nature of the vegetation and of the

rocks giving origin to the soils varies very greatly. The soils in general show a close correlation with the nature of the underlying rock. The vast majority of the soils are shallow and very stony, and most of them seem really to represent subsoils from which the superficial parts have been removed by wind action. In many cases the surface is formed of broken rock. In other parts, and especially in the western regions, a surface made up of a layer of ironstone nodules undoubtedly looks like an exposed subsoil layer. When soil proper is present it is pale in colour—grey, yellow or light red; the rocks are generally rich in salts, though lime and carbonates are not present in large quantities. Alkali may be abundant however. The reaction of the surface layer is neutral or slightly alkaline, *p*H 7–8·5. In places where water collects during rainy periods efflorescence of salts on the surface is common. Accumulations of fine silt or clay are common in valleys and depressions. They are found in the numerous pans in the western parts of the Upper Karroo. Such silts are pale yellow or light red in the smaller areas, brown or yellow-brown in the larger ones. They are alkaline, and humus is markedly lacking, as in all the soils of the arid regions. In the driest parts loose and often mobile soils are common.

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CHAPTER IV

ECOLOGICAL FACTORS AND VEGETATION

GENERAL

THE vegetation at any place exists as the result of the interactions of all the factors of the environment. The vegetation itself provides an index of the resultant action of the whole complex, the more highly developed climax communities a more exact index than others. Hence an understanding of the development is essential.

In the causes underlying distribution the factors of the environment are by no means all of equal importance ; some are so uniform everywhere that they can hardly be regarded as ecological factors. Of those that do influence distribution some have much wider effect than others. The factors themselves are very varied : some are apparent and measurable without difficulty, others are much less obvious, and some are at present very little understood. For convenience the factors can be divided into groups according to their nature and action, as Climatic, Physiographic, Edaphic, Biotic and Historical Factors. It is not proposed to enter upon any discussion of the measurement or action of the factors ; these topics are dealt with in various text-books. A few general aspects illustrative of the importance of the factor groups for the broader view of distribution must suffice.

As causal agents for distribution of the larger groups of vegetation the climatic factors are of predominant importance : the major classes, Forest, Bush, Savanna, Grass, Semi-Desert, and so forth, are controlled by these alone. The distribution of the types within these classes is due to the actions of other factors in addition.

CLIMATIC FACTORS

The main features of these have already been dealt with, and a few aspects only need be mentioned here.

Precipitation.—Rainfall itself is a limiting factor for vegetation when small in amount, irrespective of distribution through the year.

In this country 10–12 inches (25–30 cm.) or less can support only semi-desert vegetation. Over South Africa as a whole the humidity of the atmosphere is low; even in the wet season rain is not continuous and the atmosphere dries as soon as precipitation ceases. Even with a high total the plants are often exposed to conditions of drought. The length and frequency of such drought periods is an important factor; a small change in one direction or the other may be enough to allow of the establishment of a more or a less water-demanding type.

The low average humidity is less apparent on mountain ranges near the coasts where mists modify the conditions. These mists bring about a precipitation by condensation on, or by interception by, the plants. Examples that illustrate the importance of this are seen in the extension of coastal moisture-demanding vegetation on mountain ranges running through much drier types of climate.

None of the mountain ranges is of sufficient height or extent for snow to be more than a local influence on the vegetation.

Temperature.—Temperature acts on vegetation partly through its influence on the water relations, but partly more directly, chiefly through the extremes and rapid changes. The important facts to be measured in regard to temperature are the degree of warmth at the different seasons and the amount and duration of the extremes. The effects of the last are related to the water supplies.

In an elevated country with a dry atmosphere radiation is large and is a factor of more importance than has often been recognised. The prevalence and duration of frosts in the interior are very closely related to the distribution of the vegetation. The extent of the natural grasslands, for example, is largely determined by frosts: the rainfall and average summer temperatures are very much like those in the adjacent savanna, but the severity and frequency of frosts is enough to prevent tree growth in the grasslands. In the arid parts the dominance of succulents is closely related to frost frequency.

The frosts that occur are night frosts; prolonged frosts are rare. The ground does not become hard frozen except on the higher mountains, and nearly always temperatures rise rapidly in the daytime. The effects of the frost factor can be readily seen in the taller, more luxuriant plants on rocky outcrops or steep slopes. Forests are confined to slopes facing east or south and to those parts of the slope that are free from frost.

As an example of local differentiation due to frost some observations made on a ridge 4,000 feet (1,220 m.) high in the Ceres Division of the Cape Province may be given. Here there were alternating patches of sand and solid rock ; on the sand was an open community of tufted Restionaceæ, while the cracks in the rock were occupied by bushes and succulents. On a clear night in September a minimum thermometer was exposed on a rock and registered just over the freezing point. The same night a can of water standing on sand a few yards away was frozen quite solid. The following night the thermometer on the sand fell to 16° F. (— 8·8° C.). The difference in the life forms of the plants on these adjacent soils seems correlated with this temperature behaviour.

PHYSIOGRAPHIC FACTORS

The influence of the climatic factors is often modified to a large extent by the configuration of the ground : altitude, angle and direction of slope, and so on, may produce changes in the conditions affecting the plants. The effect of these physiographic factors is always an indirect one : they act through the influence on the climate. The north and south sides of a hill or valley have different conditions of evaporation and may bear different vegetation. At the boundary zone between two types one or other is developed on slopes facing north or south, often with great regularity. Where the boundary coincides with a physiographic feature it may become a definite line : examples are seen at the southern edge of the Great Karroo, where mountains mark the boundary and their base is a line separating two kinds of vegetation quite sharply. The passage to the rock of the mountains coincides with that to the other kind of vegetation. In this case the mountains obtain additional supplies of water, and at the junction a change in soil allows the more water-demanding vegetation to oust the other.

EDAPHIC FACTORS

The correlation of vegetation with soil is very general and often very apparent, but, with the exception of cases like that just mentioned, the differences between the plant cover on two adjacent kinds of soils are differences in composition more than in structure. In other words, soil differences determine the smaller divisions of the vegetation.

Soil factors are exceedingly important in the exploitation of the vegetation. The value of the land in any vegetation depends on the soil. Throughout the country there is a distinct lack of fertility in many of the soils. In part this is due to lack of lime, but not altogether. Many of the soils are deficient in nitrogen, and when disturbed for cultivation soon become poor unless additional supplies are added. The micro-organisms that carry out fixation and transformation of nitrogen can only function when suitable degrees of both moisture and temperature are present. These deficiencies in fertility, though of great practical importance, do not influence the distribution of the natural vegetation.

BIOTIC FACTORS

The influence on vegetation in its broader aspects of the activities of animals is a complex one. While direct influence is most often local, there is every reason to believe that all vegetation represents a balance between the plants and the physical factors of the environment on the one hand and animals on the other. Animals are much less closely correlated with the climatic factors owing to their mobility. Examples illustrating this are the locust, which at times extends far beyond the limits within which it is a permanent inhabitant, and migratory birds.

Grazing.—The animals which have the most obvious influence on vegetation are the gregarious herbivorous ones which originally were present in South Africa in considerable variety and vast numbers. Herds of antelope and other animals roamed over the country. The spread of settlement through the country has caused a very great reduction in the numbers. It is not too much to say that over large areas they have become very uncommon or extinct. The predatory animals that fed on them, and by keeping down the numbers helped to maintain a balance, have been equally or even more reduced. This destruction, instead of having a favouring result on the vegetation, has been followed by exactly the reverse because it coincided with the introduction of sheep, goats and horses, and a very great increase in the numbers of cattle. The grazing pressure has been increased and altered in character. The domesticated animals are less mobile and their grazing is more concentrated. Enclosure of land and reduction in size of grazing areas have intensified this.

Over the greater part of the country water supplies are limited. The herds of wild animals and the cattle originally kept by the natives certainly congregated in the vicinity of water supplies in the dry season, but in the wet season they spread over a wide area. In ordinary circumstances no part would be grazed continuously throughout the year, and hence any serious destruction was prevented. New and less favourable conditions appeared with the enclosure of the land: the numbers of grazing animals were increased, but their range was restricted and most often grazing in limited areas became continuous through the year. This herding of cattle caused trampling of the soil and very often the formation of definite tracks, especially in the neighbourhood of drinking places. The more severe and continuous grazing left no period for plant regeneration. As the rate of consumption equalled or exceeded the rate of growth changes in the vegetation appeared. The original communities were destroyed and their place taken by simpler ones which were more resistant to cropping or less palatable. In extreme cases open communities were formed where once continuous vegetation existed.

Other Animals.—Animals other than the herbivorous ones have much less obvious effects on the vegetation. Their influence is in most cases very little understood up to the present. Some are of importance in dispersal and other aspects affecting individuals. The only one that calls for any notice is the locust, and this more on account of its economic importance than because of any influence it has on vegetation. In South Africa non-migratory locusts are generally distributed: two species periodically form migratory swarms and may cause large damage to crops in their path. These two species are the Brown Locust (*Locustana pardalina*) and Red Locust (*Nomadacris septemfasciata*). The former is an inhabitant of the arid and semi-arid parts, whence swarms frequently pass into the more favoured regions. The numbers, size and range of the swarms are very variable. The red locust is more tropical and invades the country from the north. The swarms are most frequent in the warmer parts and especially the east coast belt. Swarms of the red locust are less frequent than those of the brown one, but are more destructive and they extend further.

Human Activities.—In addition to those effects already mentioned, the activities of man have had a large influence on the

vegetation. The influence is partly direct, as in forest destruction, clearing of land, planting, and so on, and partly indirect. Indirect effects are seen in burning, intensive grazing due to enclosure of stock, destruction of wild animals, controlling of rivers and water supplies, and in the introduction, whether deliberate or accidental, of alien plants.

Though South Africa has a small population which is spread over a large area, and a population of relatively recent date, the influence on the vegetation is large and widespread. The changes are mostly in simplification of communities; the climax is destroyed and replaced by others that correspond to earlier stages of development. In some places this has been carried to such an extent that the climax has come to occupy a very small part of the area. Some of the changes resulting from destruction of the natural climax are described under the different types of vegetation. One, however, deserves special mention here.

Soil Erosion.—Destruction of fully developed vegetation is very often followed by serious consequences. In a country where much of the rain falls in heavy storms, the water reaching soil dried during rainless periods does not easily penetrate. When the plant cover is not complete, the water running off is readily collected into channels and starts cutting into the surface. Such channels are specially formed where the soil has been trampled by stock and where the animals have made tracks. A channel once started very soon becomes enlarged by succeeding rains and may get quite big and form a donga. Dongas, if neglected, may become so large and so numerous that the surface layers of the soil are removed altogether. In any case channels or dongas cut into the soil form a drainage system into which water flows and also percolates from the surroundings, thus lowering the water table. The sides of dongas are bare and steep; they are not at all easily colonised owing to the instability and the dryness of the surface.

Destructive soil loss where vegetation has been disturbed does not necessarily result from the formation of dongas. Where there is no continuous plant cover and a permeable soil layer overlies a relatively impermeable one, water drains off along the top of the latter and may carry away the whole surface. This "sheet erosion" occurs most commonly where land has been cleared for cultivation, but can occur wherever the cover has been seriously reduced. It is more

prevalent on slopes of low angle ; on steep slopes dongas are formed. Sheet erosion and donga formation often go on together. Either form of erosion once started is progressive.

Soil erosion has become exceedingly prevalent throughout the country, and occurs in practically every type of vegetation. The evil is possibly most obvious in the native territories and Basutoland, but is by no means confined to them. The thing has become so serious that the Government of the Union is taking steps to deal with it and has voted a considerable sum of money for work on the question. Reclamation of affected land, preventive measures in the earlier stages, and research into the fundamental factors involved, are being carried out.

Though the whole complex of factors controls the distribution of vegetation, for a broad view of the distribution of types certain factors are predominant. The distribution of the classes of vegetation types follows very closely the distribution of the amount and seasonal character of the rainfall. Within these larger classes the separation into individual types is based on the distribution of temperature also, and this is very much influenced by topography. The soil and other factors are of importance in the distribution of the communities within a type. The accompanying map shows the distribution of the types in the country (Map 10).

Neither the types themselves nor the complexes of factors determining them are sharply separated from one another : most often one grades into the next by insensible transitions. This means that the boundaries as drawn on a map are somewhat arbitrary : there is not often a *line* of separation but rather a *broad zone*.

In a country of the size of the Union, in which distances are large and some parts not easily accessible, some regions have been little explored botanically and not at all from the standpoint of vegetation development. Hence it is inevitable that knowledge of the vegetation is unequal. In the separation of types from one another the structural characters of the climax have been emphasised : floristic features, and especially the floristic characters of developmental stages, have been given very little notice. The distribution of species or groups of species, which may appear as characteristic of a vegetation type, often extends far outside the area of the type, and, though of value in providing information on the origins and affinities

of the flora, is not of great importance in the classification of the vegetation, at least where the species involved are not part of the climax. As an example, the extension of *Ipomœa biloba* as far west as Riversdale, into vegetation quite different to that of the tropical coasts of which the plant is characteristic, cannot be said to have any great vegetational importance. Another example is the community of Ericaceous plants that occurs on the highest summits of the Drakensberg. The apparent similarities to the Sclerophyll in plant form and species do not imply any real connection. The community is a developmental phase with a climax in no way like Sclerophyll.

The classification of vegetation types adopted and the boundaries of these as shown on the map do not agree completely with any of the arrangements put forward previously. The earlier schemes were either generalised as the result of incomplete information, like those of Grisebach (1878) or Schimper (1898), or were based entirely on floristic characters, like that of Bolus (1905). More recent arrangements by Pole Evans, Bews and others approximate much more closely to the present one. The schemes have tended either to large generalised units or to smaller, more restricted, ones. An extreme case of the former is the union of Savanna and Grassland in one division.

Certain of the types have been recognised from the earliest times, though conceptions of their boundaries have been far from uniform: Grassland, Tree Savanna, Sclerophyll are cases in point. The semi-desert of the Karroo has always been separated, though it has been subdivided in almost as many ways as there are accounts of it. The least agreement has been on the forests, largely on account of their small area. The Temperate Forest has very often been united with the Sclerophyll, though as long ago as 1898 Schimper clearly pointed out the essential ecological differences between the two.

The scheme here adopted does not claim any finality; increase in knowledge will inevitably bring about modifications. It does, however, claim to present in general terms the relations of the main climax communities to the various types of climate occurring in the country.

In nomenclature no attempt has been made to coin technical terms: descriptive names are generally used. Local names which have a definite connotation have been employed; where such are

less exact they are rejected. Such names as Karroo, High Veld, Thorn Veld, and others in common use, are not used, since none of them is restricted to any one type of vegetation. The term "Sclerophyll" is used in place of "Cape Bush," "Fynbos," "South-western Vegetation," "Macchia," or others that have been employed. This is done because the ecological similarities with Sclerophyll vegetation in other countries is so great and so well established. No one of the alternative names is free from objection. It is to be hoped that, as the study of vegetation progresses and real similarities between that of different countries are made out, a uniform scheme of names, at any rate for the larger groups, may be devised.

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CHAPTER V

BUSH (SCLEROPHYLL) VEGETATION

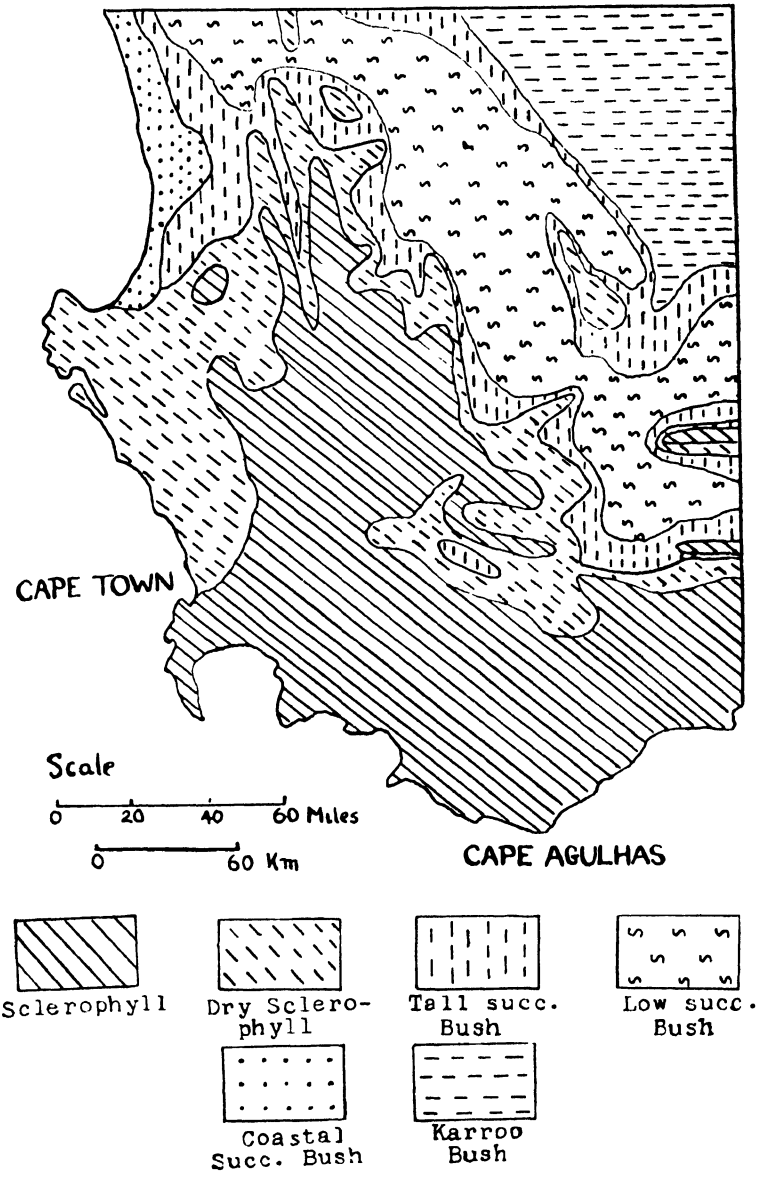
GENERAL

THIS is a bush type, made up of shrubs with evergreen leaves of small size and hard in texture, which occupies the regions of winter rainfall where the total is not less than 12 inches (30 cm.). Though this type occupies only a small fraction of the total area of the country, it is in many ways the best known and the most studied. It has been recognised as a distinctive type of vegetation from the earliest times. Geographically, the type is limited to the south and south-west coastal belts. It is separated from the vegetation of the arid regions by the ranges of folded mountains of the Cape System of rocks.

The actual boundaries of the area are somewhat irregular, owing to the fact that the type extends along mountain ranges, much beyond the regions where it covers the low ground. The main boundary runs from near Humansdorp in the east, along the coastal mountains to the Hex River, and northwards to the Cedarberg. The northern boundary on the lower ground runs from Clanwilliam to St. Helena Bay. Eastward the type extends beyond these limits to the Winterberg and Zuurberg ranges, with small patches as far as the Amatola Mountains. It occurs on the various ranges that rise in and around the Little Karroo. In the north it extends along the mountains of Namaqualand, with outliers on the Hantamsberg north of Calvinia.

The region is one with considerable diversity in local climate and topography. The rainfall varies from over 100 inches (250 cm.) in the mountains to 12 inches (30 cm.). Though most characteristically developed in regions with a dry summer season, this vegetation extends at its eastern limits into conditions with uniformly distributed rainfall. Throughout the extent, however, the six winter months receive at least half of the total amount.

The region consists of a coastal plain, or rather peneplain, with



MAP 11.—Distribution of Vegetation Types in the South-Western Cape Province.

ranges of steep-sided mountains which may reach 7,000 feet (2,133 m.) in height; most of the ranges have areas over 3,000–4,000 feet (915-1,220 m.). The upper parts of the mountains have a climate that is moister in character than that of the lower ground. Not only is the rainfall greater, but the summer drought is rendered less severe by mists brought by the south and south-west winds. These mists settle on the mountains and bring quite an appreciable quantity of moisture, though they do not influence the lower levels.

Though there is a considerable variety in the vegetation in correlation with the ranges of climate and altitude, certain distinctive features are common to all the communities. The prevailing plant form is a shrub or undershrub, only occasionally reaching the stature of a small tree, with evergreen, hard leaves. The leaves are either very small and heath-like, or when broader have a dull surface. The smaller bushes have erect, wiry stems. Grasses or grass-like plants are not at all common, but reed-like, often tufted, plants mostly belonging to the Restionaceæ, are exceedingly abundant. Geophytes are numerous.

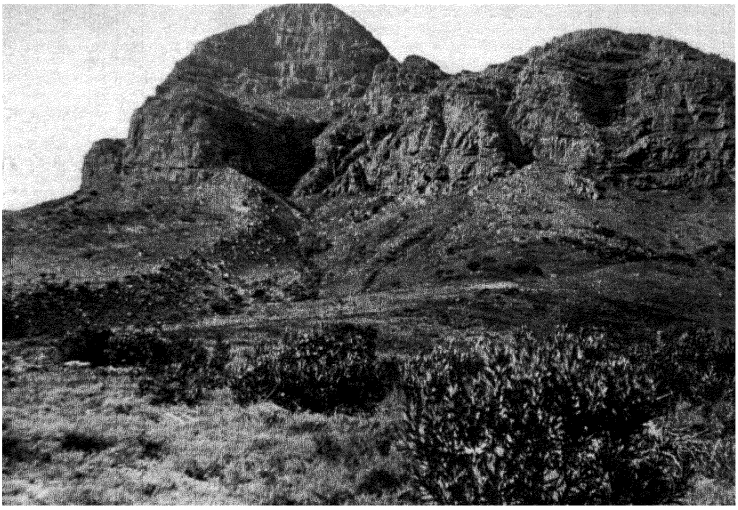
There is a decided absence of perennial social species, and the communities are made up of a number of species of similar form associated together. The absence of social species and the dominance of shrubs results in an incomplete cover to the soil. The upper portions of the plants often form a dense stratum, but at the soil level, even in the more luxuriant vegetation, 15 per cent. of the area is bare.

The Sclerophyll vegetation has a very distinct flora and contains a large number of endemic species. Communities of exactly similar structure separated by quite short distances often have very great differences in composition.

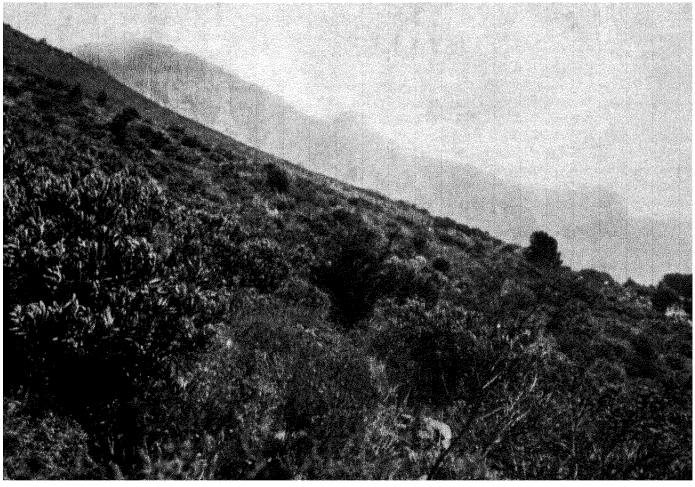
The vegetation can be separated into five subdivisions :—

1. Sclerophyll Bush.
2. Wet Sclerophyll Bush.
3. Mountain Bush.
4. Dry Sclerophyll Bush.
5. Rhenosterveld.

In addition there are communities that are transitional in their characters between the true Sclerophyll type and the adjacent ones.



PHOT. 1.—SCLEROPHYLL. Much-burned slopes at Hawaqua Peak, Wellington, Cape Province. Relict bushes of *Protea nerifolia*, and *Stoebe plumosa* (white, foreground) following a fire: more recently burned ground behind. Relict of a forest community in gully.



PHOT. 2.—SCLEROPHYLL BUSH approaching climax. West slopes of Table Mountain. *Protea lepidocarpodendron*, *Metalasia muricata*, *Aspalathus chenopoda*, etc. Introduced *Pinus pinea* behind.

[*Facing p.* 88.

SCLEROPHYLL BUSH

This is the type of the plains and lower slopes where the rainfall is between 20 and 30 inches (50–76 cm.). It occurs from sea-level to about 3,000 feet (915 m.).

The climax community is a relatively dense and complex one, made up of bushes or occasionally of small trees. In its fully developed form it has three layers. The uppermost consists of large bushes, 5–8 feet (1·5–2·5 m.) high, most of which have flat leaves of moderate size, but hard and with a dull surface. Proteaceous shrubs are abundant in this upper layer. Of these *Protea*, *Leucadendron* and *Leucospermum* are abundant, together with *Gymnosporia*, *Heeria* and a number of others. The uppermost layer is rarely continuous. Below is a dense layer of small shrubs with thin and more flexible stems and typically small heath-like leaves. A large variety of plants takes part in the building of this stratum. Shrubby members of Compositæ, Ericaceæ, Rutaceæ and many others are abundant. Below and between these bushes are smaller woody plants, herbs and geophytes in considerable numbers. Restionaceæ are often very abundant in the lower strata. Annuals are usually few in number.

The height, density and floristic composition of the various layers show great diversity from place to place, but the structural characters are constant. In sheltered and moist places the upper layer may attain a height of 12–15 feet (3·5–4 m.) and be quite continuous. In the drier parts the bushes of the upper layer are quite separate from one another. In some of the driest places the whole community may be open in character.

The climax community is not at all common. In fact, over considerable stretches it is absent or, at most, represented by very small patches. The greater part is occupied by much simpler types of community which are single- or two-layered : these result from destruction of the climax, usually by fire.

WET SCLEROPHYLL BUSH

This is a luxuriant type of bush occurring where the soil has permanent supplies of water. The general structure is similar to the first type, but the growth is denser and less xerophytic. There is an absence of hard leathery leaves and a prevalence of soft ones,

though of small size. Most of the larger plants have soft heath-like leaves. *Berzelia* and some of the taller species of *Erica* are very common ; plants with larger leaves are represented by *Leucadendron*, *Cliffortia* and others.

The bushes here often form a dense growth up to 10 feet (3 m.) or more. Layering is less definite, but numerous small plants, including several of social habit, occur beneath the dominants. This type is found only on wet soils, but is not wholly a streamside community. It is especially widespread in the regions of higher rainfall and has been called " Hygrophilous Macchia."

MOUNTAIN BUSH

This is found at altitudes over 3,000 feet (915 m.) near the coast and further inland under conditions of lower temperature, higher rainfall and summer mists. Even as far inland as the ranges that form the southern boundary of the Great Karroo these mists occur. Snow falls on the mountains in winter but does not persist for long.

The general structure of the vegetation is very much like that at the lower levels, but the bushes are of smaller size and the stratification is less complete. Larger bushes with broader leaves are much less abundant and often confined to sheltered places. Small heath-like bushes and Restionaceæ form the bulk of the communities.

Many of the bushes are slender and often single-stemmed, reaching a height of 2–5 feet (60–150 cm.), and frequently rising well above the level of the surrounding plants. This form is found in a number of different plants, and may be correlated with snowfall and wind exposure. That exposure is a factor is seen in the growth of a number of bushes which are erect in valleys but prostrate on the upper slopes. At the highest levels many plants assume a prostrate or semi-prostrate habit. The cushion habit, so characteristic of mountain regions generally, is rare here and only exhibited by a few plants. Annuals are very rare in the mountain communities.

The Mountain Bush has a very definite floristic composition and has few species in common with the vegetation at lower levels. Yet the similarities of structure and plant form are very great. The Mountain Bush agrees with Sclerophyll Bush in structure, life form and in lack of species dominance. It is made up of a number of plants of similar form associated together. The general features of

the flora are the same as at a lower altitude: there is the same prevalence of certain families or genera. Together the similarities are so great that the separation of the upland and lowland vegetation is not possible despite the differences in climate. All gradations from this to the typical Sclerophyll Bush occur.

None of the mountains of the South-West Cape region can be said to have a true alpine vegetation, or even a vegetation really distinct in its character from that of the lower parts.

The general dominance of small ericoid bushes on a soil with large accumulations of humus in these mountain communities suggests a comparison with the heaths of the Northern Hemisphere. A possible parallel can be drawn, both in structure and habitat relations, between the Sclerophyll Bush and Mountain Bush, on the one hand, and Macchia and Heath on the other. Much more intensive work is required before anything like a definite conclusion can be drawn. Another possible comparison is between the Mountain Bush and the upland types of vegetation which are found on the mountains of New Zealand and Tasmania. The Mountain Bush is drier, but this might be the result of the difference in latitude and of the structure of the mountains, which does not allow of large areas capable of collecting water. The cushion plant, which is so characteristic of the southern areas, is here absent.

DRY SCLEROPHYLL BUSH

This is developed in regions of lower rainfall where the precipitation is between 20 and 15 inches (50–38 cm.). Every grade of transition between this and the typical Sclerophyll Bush occurs and no sharp line of demarcation can be made between them. The vegetation in the drier parts is, however, very different. The structure is simpler, more often open in character, and not distinctly layered. The bushes are generally characterised by small, dry, flat leaves. The number of those with ericoid leaves is much less, though some of these may attain dominance, for example, *Passerina* spp. Succulent plants are often associated with the bushes, both larger ones and small low-growing plants. Geophytes and annuals are common.

The dry communities show a wide range of variation with local conditions. The dry northern portions are characterised by communities in which the bush with small flat leaves predominates, whereas in the eastern parts the larger succulents, and especially

Aloe ferox, are very abundant. The reed-like Restionaceæ are usually confined to sands in these dry localities, where they may form pure communities. The Dry Sclerophyll Bush is found especially along the inland margin of the Sclerophyll region. It is especially well developed in the northern parts, as on the mountain slopes in Namaqualand.

RHENOSTERVELD

At the limit of moisture permitting the development of vegetation of the Sclerophyll type there are simple open communities, very often characterised by the dominance of a single species. *Pteronia* spp. and *Elytropappus rhinocerotis* (Rhenosterbush) are the commonest, and the last is very much the most extensive. These are shrubby plants 1–3 feet (30 90 cm.) in height: the Rhenosterbush has cupressoid twigs of a grey colour. These plants form open communities in which associated shrubs are quite subsidiary in quantity. The *Pteronia* communities occur as a marginal zone between the Sclerophyll vegetation and Semi-Desert vegetation. The Rhenosterbush communities are often more extended, occurring both as a transitional zone and also in other dry areas, where they are quite apart from the Sclerophyll communities. Examples can be seen on some of the higher mountains rising from the Karroo, such as the Sneeuwberg north of Graaff Reinet. The community is most often found on the deeper fine-grained soils, but is not confined to them. Rhenosterveld represents the most arid kind of Sclerophyll vegetation. That it is really part of this type and does not belong to the Semi-Desert is seen in the leaf and growth characters, and still more in the dominants being characteristic of developmental stages and secondary communities in the moister parts.

Transitions.—The Sclerophyll type is so distinctive in its structure and its flora, and exists under such sharply defined conditions, that the transitions to other types are of considerable interest. In the drier parts in the north and north-west it merges gradually into the Semi-Desert, which also occurs in winter rain conditions. On the low-lying sandy ground near the coast north from Table Bay there are communities in which succulent plants become exceedingly abundant. These form closed bush communities, 3–4 feet (90–120 cm.) high, in which at least half the plants have succulent leaves or stems.

At the eastern limits of the region there are communities which are intermediate between the Sclerophyll and Temperate Savanna types. The vegetation is made up of low shrubs or under-shrubs along with grasses. Sometimes one element predominates, sometimes the other. In some sheltered spots there occurs a community with an undergrowth of grass with some under-shrubs, in which larger bushes, as *Protea*, *Acacia* and others, are scattered.

Development and Succession.—The main stages of the succession have been investigated. The many-layered climax is the end phase of a development through communities of simpler structure. The earlier stages have less variety of life form and composition. After the pioneer stages one or two species may attain temporary dominance. Low-growing undershrubs precede the erect ericoid bushes. The earlier phases are often characterised by small flat leaves, while the ericoid type dominates later. The general series of stages parallels very closely the series passed through from the driest to the moister portions of the Sclerophyll vegetation.

Succulents are often prominent in the earlier stages, especially on sandy or rocky soils. Communities in which succulents persist are stages fixed by local conditions that prevent further development.

Modifications.—Alterations of the vegetation as a result of man's activity are probably more widespread and general in the Sclerophyll than in any other type in the country. The main agent has been fire, which has affected all but the very driest portions. The effects of fire have become so widespread that over much of the region climax communities are exceedingly rare, and the existing plant cover is composed of a series of phases of regeneration which are irregularly arranged, the separation of one from another depending on the dates of the fires and not on any features of the environment. The connections of the various resulting communities with one another or with the climax are complicated by the irregular intervals that occur between successive fires. They are generally much more frequent than the times required for complete regeneration of the vegetation. A very frequent succession of fires results in the establishment of a low bush community which is not layered. Communities dominated by Restionaceæ in the mountains, and by low ericoid shrubs in the valleys, are examples.

Burning of this vegetation in the dry season has been taking place for centuries. It was carried on by the Hottentots before the

arrival of the European. In this shrub vegetation, which becomes very dry and much of which is resinous, a fire once started easily extends far beyond the intended limits and rapidly destroys a wide area.

The practice of burning was originally employed to clear the land. It is often employed in the hope of improving or creating pasturage. The general result is to send back the succession to earlier stages. This may be taken advantage of for practical purposes. Thus on sandy soils a community of Restionaceæ may be perpetuated by judicious burning and provide pasturage for sheep. It has been found that in such cases if burning is carried out after rain the reeds survive but bushes are killed. While this sort of advantageous result may be obtained in a few cases, most commonly the effects of burning are undoubtedly deleterious. The destruction of the vegetation leaves the soil exposed to erosion by wind or rain. Even if not removed the soil rapidly loses water and humus. The removal or impoverishment of the soil renders the re-growth of the vegetation slower and often brings about the development of poor, dry communities efficient neither as soil binders nor as pasture. The bare, or partially bare, condition of the mountains that has resulted from continued burning and erosion renders them incapable of conserving water.

Communities resulting from interference with the vegetation are often characterised by the dominance of a single species. Of such, one of the commonest and most extensive is completely dominated by *Elytropappus rhinocerotis*, Rhenosterbush. This forms extensive tracts of secondary vegetation. It covers most of the clay-like soils on the lower grounds. Such soils have been much cultivated and over large areas the original vegetation has disappeared ; all uncultivated areas are now covered by Rhenosterbush. In fact, *Elytropappus* is far the commonest plant on these soils, though its present dominance is certainly secondary. All farmers and others connected with the land are agreed that the plant is much more abundant than it once was, and there is some evidence that its range has increased. The belief in the recent extension of the area of the plant has led to fanciful statements that the species is not indigenous, but introduced from the East Indies or the Belgian Congo. There is no foundation at all for such ideas : the plant belongs to a genus endemic to the Sclerophyll region and not found outside it ; it is

prominent in the normal development and forms stable communities in the drier parts. Its great spread and present abundance are due to destruction of the more advanced stages. The plant reproduces from seed very rapidly after fire or clearing; it is drought resistant and makes small demands on humus or other special features in the soil. It is impregnated with wax and unpalatable to grazing animals.

The secondary Rhenosterbush communities differ from the stable ones of the drier parts in being almost or quite closed. The bushes may be 3 feet (1 m.) or more high. Under such conditions the plant cannot regenerate and, as the bushes are not long-lived, is replaced by others whose seedlings can withstand shade. Even under favourable conditions its period of dominance may be only eight to ten years. Continued disturbance helps to perpetuate the plant.

In the vicinity of towns and villages a number of alien species have spread and established themselves in the vegetation. Some of these are annuals which have little apparent effect, but others are shrubs or trees which have either altered or completely changed the character of the vegetation. On the Cape Flats, for example, the Australian wattles, *Acacia saligna* and *A. cyclops*, have spread over quite large areas and become completely dominant, with an elimination of most of the original plants. *Pinus pinaster*, *Hakea spp.*, *Albizzia lophantha*, *Acacia longifolia* and *Eucalyptus spp.* are behaving in a similar way on some of the mountain slopes.

In the drier areas the demand for firewood has resulted in the cutting out of the larger bushes and a simplification of the vegetation. The Sclerophyll vegetation is intolerant of trampling, and round settlements open communities of introduced plants are formed.

Utilisation.—The Sclerophyll vegetation has little value either in natural products or for grazing purposes. The attempt to create pastures has been responsible for most of the wholesale burning.

Natural Products.—The most important is aloes, used for "bitter aloes," which is obtained from *Aloe ferox* in the Dry Sclerophyll Bush of the eastern regions. Aloes are not cultivated. The export in 1932 was 847,710 lbs.

Buchu (*Barosma spp.*), used as a drug, is collected in the mountains, especially the Cedarberg, and a small export to America is carried on: 162,634 lbs., valued at £3,489, were exported in 1930.

The shoots of *Chondropetalum tectorum* are used locally for thatching. Berry wax is obtained from the fruit of *Myrica cordifolia* and used locally as a substitute for beeswax. In the vicinity of Cape Town a small trade is carried on in wild flowers.

Cultivation.—Though lacking in natural products, the soils on which this vegetation naturally grows are valuable for cultivation. The coastal plain has been much used for the growing of grain. Wheat, oats and barley are grown; over 60 per cent. of the total for the country is grown here. Fruit-growing is carried on at the base of the mountains: grapes, various kinds of deciduous fruit-trees and some others are produced. Vines are practically confined to this type, and it supports much the largest part of the deciduous fruit trade. *Citrus* is grown under irrigation. Other crops are tobacco, lucerne and vegetables.

Afforestation.—Tree planting commenced very soon after the settlement of Europeans at the Cape. At first planting was for ornament and shade, but very soon was undertaken to maintain a timber supply to replace the destruction of the native trees. In more modern times most of the planting is undertaken by the Government and little by individuals. It is mainly on the mountain slopes, on land of little value for cultivation. *Pinus pinaster* is the tree planted most extensively. *P. radiata* (*P. insignis*) is planted to a less extent. Other pines are planted, but very much less. *P. pinaster* especially reproduces from seed very easily. *Eucalyptus* spp. have been planted also and make excellent growth, but owing to difficulties of seasoning are not grown so much as the conifers.

At the present time the Government plantations in this type cover an area of over 50,000 acres, of which nearly three-quarters is under pines. Of other trees planted, the Australian wattles, *Acacia saligna*, *A. cyclops*, and to a less extent *A. longifolia*, have proved efficient for the fixing of loose sands. *Populus canescens* is commonly grown near water and is sold for matchwood. The oak, *Quercus robur*, which was freely planted in earlier times, is of no value for timber and is now only grown for ornament and shade.

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See also Nos. (4), (9), (12), (21) of References to Chap. IV.

CHAPTER VI

FOREST VEGETATION

GENERAL

Forest vegetation is of very limited extent in South Africa, and is only represented by evergreen forest of the rain-forest type. Less than 0·3 per cent. of the surface is now covered by high forest. Much the greatest part of the country has a decidedly seasonal rainfall and prolonged dry seasons, and generally an evaporation rate in excess of the total precipitation. Such conditions are definitely adverse to the development of this kind of forest, which requires an adequate and evenly distributed moisture supply, combined with freedom from extreme temperature fluctuations.

However, though very limited in extent, the forests of the country form a vegetation of considerable interest; indeed their very rarity increases their importance. The forests, none of which is at all extensive, are found over much of the coast belt from Natal to the southern part of the Cape Province. They also occur in the Transvaal, on the escarpment and on some of the northern mountain ranges.

Within the limits of the rather large area where forests occur there is a considerable range of rainfall and temperature, and, correlated with this variation in conditions, more than one type of forest can be recognised. Since the range of conditions within which forest development can occur at all is limited, and the variations within this range are in minor factors which are not sharply separated from one another either geographically or otherwise, it is not unexpected that transitions from one type to another should be found. While examples from widely separated localities are quite obviously distinct, it is almost always possible to find other examples in the intervening region with intermediate characters, and indeed very often it is possible to find a complete series of gradations from one extreme to the other.

All the forests exhibit certain common characteristics in the structure of the community, in leaf characters, and very definitely

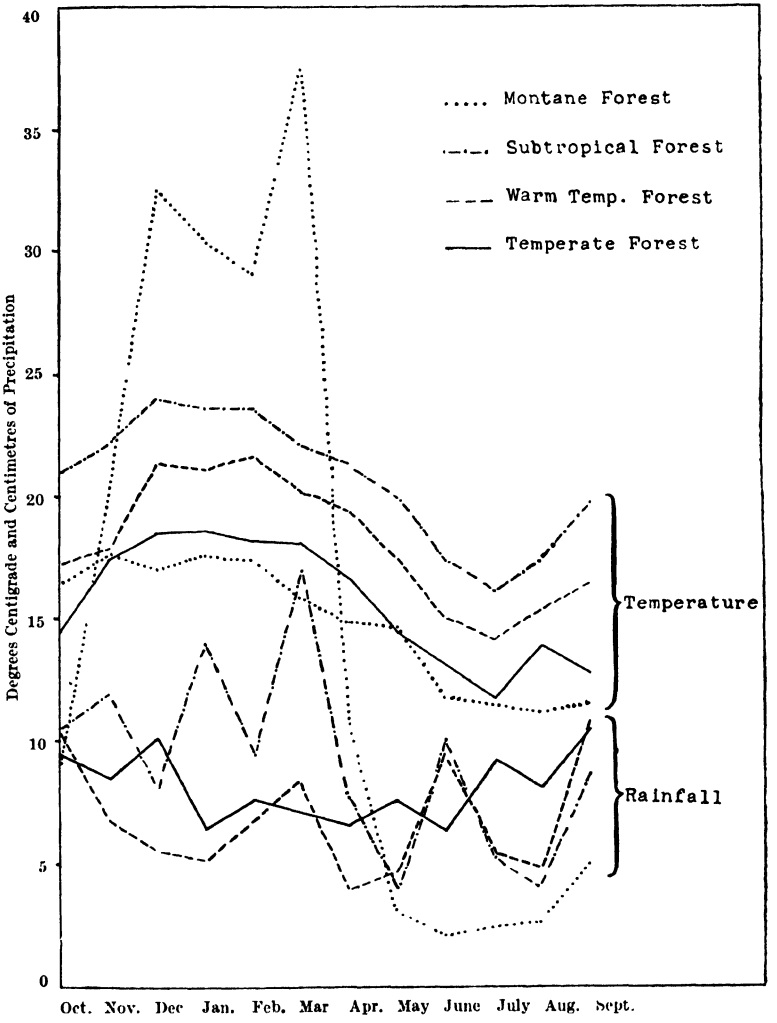


FIG. 22.—Hydrotherm Chart for four types of Forest.

in some features of the floristic composition. The natural forests are all evergreen in character, with dark, more or less polished, leaves. Many genera and even some species are common throughout the whole range of forests.

The similarities between the various forests are so great that some writers have grouped them all as one type, though if this is done the resulting unit is one that is only capable of definition in the most general terms.

Work of a detailed kind has been carried out so far on a very limited number of the forests, and until very much more has been done any classification that is attempted must be tentative in character. The forest communities are here grouped into four divisions, which are separable from one another in features of structure, composition and relations to the habitat. The divisions are :—

1. Temperate Forest.
2. Warm Temperate Forest.
3. Sub-tropical Forest.
4. Montane Forest.

While in its typical development each of these forms a distinct type, all stages of transition occur from one to another, and many examples can be found which are not readily referred to any one type. The accompanying table and hydrotherm chart will illustrate the essential characters of the habitat of these four types. In each case the figures are the average of four stations :—

TABLE 27.—*Rainfall and Temperature of Forests*

Mean Temperatures.

	Temperate		Warm Temperate		Sub-tropical.		Montane	
	°F.	°C.	°F	°C	°F.	°C.	°F.	°C.
Oct.	58·2	14·5	64·3	17·8	69·9	21·1	62·1	16·6
Nov.	63·5	17·5	66·4	19·0	72·1	22·2	64·2	17·8
Dec.	65·5	18·6	70 8	21·5	75·6	24·0	63·0	17·2
Jan.	65 7	18·7	70·3	21·3	74·9	23·8	64·0	17·7
Feb.	64·9	18·3	71·3	21·7	74·6	23·7	63·7	17·6
Mar.	64·8	18·2	68·0	20·0	71·9	22·2	60·8	16·0
Apr.	62·1	16 6	67·1	19·5	70·8	21·5	59·1	15·0
May	58·2	14·5	63·6	17·5	68·0	20·0	58·5	14·7
June	55·6	13·1	59·3	15·1	63·6	17·5	53·4	11·9
July	53·2	11·8	57·5	14·2	61·2	16·2	52·9	11·6
Aug.	57·2	14·0	60·0	15·5	63·6	17·5	52·6	11·4
Sept.	55·2	12·9	61·9	16·6	67·7	19·9	61·1	16·1

Rainfall.

	Temperate		Warm Temperate		Sub-tropical		Montane.	
	in.	cm	in	cm	in.	cm.	in.	cm.
Oct.	3·78	9·60	4·12	10·46	4·21	10·69	3·58	9·09
Nov.	2 91	7·36	2 74	6 96	4·73	12 01	7·72	19·60
Dec.	4·09	10·38	2·22	5·64	3·19	8·10	12·81	32·53
Jan.	2·57	6·52	2·04	5·18	5·59	14·20	11·99	30·54
Feb.	3·00	7 62	2·62	6 65	3·76	9 55	11 48	29 15
Mar.	2 85	7 24	3 38	8·56	6·73	17·09	14·82	37 64
Apr.	2·67	6·78	1 60	4·06	3·07	7·80	4·22	10 71
May	3·04	7·72	1·66	4·21	1·61	4·09	1·24	3·14
June	2·57	6 42	3·78	9·60	4·11	10·44	0 85	2·15
July	3·61	9·17	2.27	5·76	2·24	5·69	0·97	2·46
Aug.	3 28	8·33	1·93	4 90	1·61	4·09	1·08	2·74
Sept.	4·20	10 66	4·32	10·97	3·47	8·81	2·04	5·18

TEMPERATE FOREST

This is a characteristic type that has been frequently compared with both the "Laurel Forests" and "Temperate Rain Forests" in other countries. Of the various types in this country it is the one which is best known and has received the greatest amount of study.

This forest attains its maximum development on the strip of country forming the narrow coast belt between the mountains and the sea between George on the west and Humansdorp on the east. Here forest forms the natural climax over most of the ground up to an altitude of 2,500 3,000 feet (760 915 m.). This strip receives copious rainfall distributed through the year.

Forest of this kind is not confined to this strip of country; to the west small forest areas are found in the better watered ravines of the coastal slopes of the mountains through most of the winter rainfall area. To the east forests of this kind occur on the upper seaward slopes of the higher mountains. Examples are found on the Amatola Mountains at 3,000 4,000 feet (915 1,220 m.), and on the Drakensberg escarpment in Natal at 4,000 feet (1,220 m.) and over. Other patches occur on the higher mountains in Zululand and as small outliers in Basutoland.

In all these stations there are the same climatic conditions: uniformly distributed moisture, either from rain or mists, relatively low temperatures and freedom from frosts. As might be expected, a community distributed over so wide an area shows considerable variations in floristic composition, especially when extreme examples are compared. There are, however, throughout, certain common characters. As extreme cases, examples may be taken from the slopes of Table Mountain at 1,000 feet (305 m.) and from the eastern

slopes of the Natal Drakensberg at 5,000 feet (1,525 m.). In the former there were twelve species of trees in the canopy, in the latter eighteen. Of these four were common to both and four others were represented by the same genus but different though allied species. All gradations occur in the intervening country.

In spite of this floristic range the vegetational features are remarkably constant throughout. The community is a complex, stratified one : there are two layers of trees of which the upper is not continuous. This gives an irregular external view to the canopy which is very characteristic. There is very rarely any definite dominant species ; several make up the canopy and share dominance. There is, in fact, life form dominance not species dominance. The shrubs below the trees do not as a rule form a continuous layer. Lianes, though represented by few species, are often abundant, and epiphytes are a characteristic feature of the moister parts.

The height of the canopy varies a good deal. In the more favoured spots the largest trees (*Podocarpus*) may reach a height of 150 feet (45 m.) or more, while 100 feet (30 m.) is attained by numbers of species. An average height would be between 30 and 70 feet (9-21 m.).

The trees, almost without exception, are evergreen, and most have small elliptical leaves not over 3 × 1 inches (7 × 2·5 cm.). The leaves are most often simple : the few species with compound leaves have the leaflets of the general size and shape. The leaves are dark green, firm in texture, and highly polished on the upper side. Most are quite glabrous, a few are wax-covered, and practically all have the stomata confined to the lower side. Even *Podocarpus* has leaves that approach closely to the type. This uniformity of leaf gives the forest a very dark colour which, along with the irregular exterior, gives easily recognised features. There are, of course, some exceptions to this uniformity of leaf type ; among the shrubs and lower trees there are several, but large-leaved plants are quite exceptional.

The forests are dense and a great reduction of light occurs in the lower strata. In many parts the ground vegetation is made up almost entirely of ferns.

Within the Temperate Forest type a number of communities exist which are differentiated from one another by local factors. The type can be conveniently divided into three main groups :—

1. Dry Forest.
2. Wet Forest.
3. Riverbank Forest.

Dry Forest.—This is much the most extensive of the divisions, having *Podocarpus* associated with a variety of trees; *Olea* is often very common. A distinct though not continuous shrub layer is often present. The field layer is composed of various ferns, with *Morœa iridioides*, *Schœnoxiphium* and others. Lianes may be abundant, but epiphytes are not very common. On shallow soils the ground layer may be sparse and composed largely of mosses. On very shallow soils the trees are stunted and bushes more abundant. At altitudes near the limit for the forest, or near the sea, the trees are small and the differentiation of layers becomes obliterated. Such stunted parts usually have a very sparse ground vegetation.

Wet Forest.—This occurs on low ground in valleys and in places where the soil is permanently wet. The chief trees are different; *Podocarpus* is often quite absent. *Cunonia capensis* is the characteristic species. At Knysna it is associated with *Platylophus trifoliatus*. Beneath the trees is a layer with few shrubs but a very abundant tree fern, *Hemitelia capensis*. This tree fern may form a continuous stratum. The ground is covered by moisture- and shade-loving ferns, filmy ferns and mosses. Epiphytes are abundant but lianes not common. Where the ground water is well aërated tree ferns are less abundant or absent, and their place is taken by large herbs or slightly woody plants.

Riverbank Forest.—Fringing forest communities are found along most of the permanent rivers, even far outside the climatic limits of forest growth. Such communities may be a mere fringing line of trees or more extensive. The actual nature of the trees building up these communities varies very much in different places. Within the area of the Sclerophyll type the trees or shrubs forming them are plants characteristic of the forests or of the developmental phases of the forest. In the drier regions the trees are generally deciduous, with evergreens confined to the largest stretches. Very good examples are found along the banks of the Orange River, where in places quite dense groves occur in which the trees are deciduous except for local groups. It would appear that the deciduous tree community is a forerunner of the evergreen forest. Very often, owing to periodic floods, or changes of river channel, development

cannot pass beyond the deciduous phase except under certain local conditions.

The Riverbank or fringing forests, though not at all extensive, frequently form a very striking contrast to the surrounding vegetation.

Modifications.—The Temperate forests that exist at the present time represent, no doubt, only a small remnant of the area occupied at one time. Forests are now found as isolated patches of limited extent, often, though not entirely, confined to ravines. They alternate with bush communities of the Sclerophyll type. The diminution of the forests has been due to many causes; wood-cutting is one, but the most important is burning. In the Knysna-Zitzikama region, for example, evidence of fire destruction can be seen at the margins of practically every forest patch. It appears in dead trees, isolated relict scraps of woodland, isolated trees or tree stumps, and indented margins that are without relation to soil or topography. The alternation of forest and bush is also without relation to habitat. There has been and still is a progressive diminution of forest.

Cutting of timber has brought about considerable alterations. Very often the rate of cutting has exceeded the normal growth of the forest and a simplification of the community and a lessening of shading results. In places cutting has been carried to such an extent that the forest has been changed to a scrub of shrubs without any large trees. Such areas regenerate when left undisturbed and protected from fire, but the replacement of the forest is very slow. The slow growth has been the reason for other changes; alien trees have been planted in gaps and clearings. These aliens flourish, but often with deleterious effects on the original plants, largely on account of the reduction in soil water that they bring about.

Where selective felling has taken place the additional light that penetrates allows many shrubs and gregarious herbs or under-shrubs which are not found in the untouched community to obtain a foothold and become very abundant. The amount and density of these plants varies with the amount of light that is admitted. Where forests are cleared completely their place is taken by Sclerophyll communities, in which very often a number of these light-demanding plants occur.

Development and Succession.—The forest is a complex community and the trees composing it are of slow growth, so that long periods

are needed for its establishment. After destruction tree seedlings do not come up on bare soil or under Sclerophyll Bush. Most of them require a considerable amount of protection without too great light reduction.

Around the margins of forest patches and in openings in the canopy there is present a community of shrubs and other plants of the kind noted above. This may be termed the Mixed Shrub Community, and certainly represents a stage in forest regeneration. Seedlings and young trees can establish themselves in it and would in time dominate the vegetation. In some cases *Virgilia capensis* becomes dominant in an almost pure community, either starting from or replacing the Mixed Shrub, and forest trees regenerate under the light shade so cast. The *Virgilia* woodland is found along streams and in very sheltered places ; it is often formed as a marginal zone round high forest.

The Mixed Shrub community often occurs along streams and in sheltered ravines even outside the limits of forest itself and forms a stage which cannot attain full development.

Vegetation of the same nature is seen in allied scrub communities, of which characteristic examples occur on the coasts to the west of the forest region, especially on sands. The scrub varies from an open to a very dense community of shrubs and small trees, in which *Sideroxylon inerme* often becomes dominant. *Aloe ferox* and *Aloe arborescens*, with other succulents, are common in the development of such scrub. Coastal scrub of this kind, in varying stages of development, is found in patches all along the south coast from Knysna to Cape Town.

Another scrub community that probably represents an arrested phase of forest development is that characterised by *Widdringtonia juniperoides*, which is found between 3,000 and 5,000 feet (915–1,525 m.) on the Cedarberg Mountains. This endemic gymnosperm forms a rather open community on rocky soils, attaining its greatest development in ravines, where it is associated with many plants of the mixed shrub community. This "Cedar" scrub now exists only as extremely reduced remnants. Nowhere does it form at all dense growth or real forest. Its general structure is that of the communities associated with forest development, further advance of which is here prevented by the dry conditions. The common *Widdringtonia cupressoides* is generally associated with the Mixed Shrub community.

In the Drakensberg region an exactly similar *rôle* is played by scrub in which *Leucosidea sericea* is dominant or very abundant. In this region the possible habitats for the fully developed forest are strictly limited, and fires are very much less frequent than in the western region. The vegetation generally is less disturbed and much of the scrub-covered ground is in situations where exposure to frosts or other adverse factors renders further development to forest not possible.

The earlier phases of the development have been studied only to a small extent. Some of these seem closely related to the phases of the wetter parts of the Sclerophyll. The phases that lead to the forest soon become distinguished by the abundance of plants with soft, flat leaves and a diminution of the heath-like or hard-leaved species. One example of primary succession may be mentioned. In slow-flowing rivers and pools, where the water is free from silt, the endemic *Prionium serratum* forms the first stage in the development. This plant, with its branching stems and large tufts of leaves, builds up banks or islands which form the starting point for others. Large reed-like Restionaceæ and some hydrophytic bushes are the first to become established.

The following scheme gives the outlines of the main lines of the succession :—

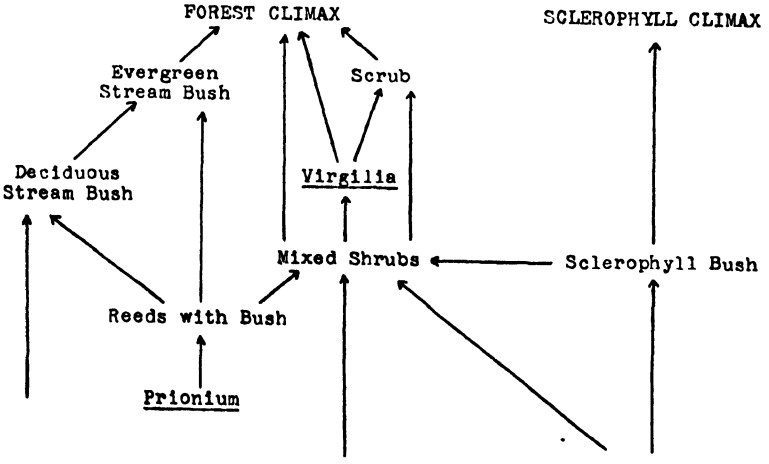


FIG. 23.—Successions in Temperate Forest.

The commonly observed phenomenon that forest once destroyed does not reproduce, but is replaced by stable, or apparently stable, Sclerophyll communities, is explainable on the climatic requirements of the two types. Forest can only develop where perennial moisture is found. A large mass of forest can spread out by producing the necessary conditions from its own structure, but, once destroyed, regeneration is possible only under the most favourable conditions. The Sclerophyll, demanding less water, develops in its place. With very long periods of time without disturbance the forest might recapture the ground, but under modern conditions this is most unlikely to occur.

Utilisation and Natural Products.—The forests have for long been exploited for timber. During the year 1933, 360 705 cubic feet of timber, most of which was used for railway sleepers, was obtained. About 70 per cent. of this was Yellowwood (*Podocarpus*). The supplies of Stinkwood (*Ocotea*) of large size are becoming very much reduced; the same is happening to several other species.

Very little has been done in the planting of native trees. Some plantations of Cedar (*Widdringtonia juniperoides*) have been established in the Cedarberg, but the rate of growth is slow and some of the plantations have been made without regard to the natural habitat of the tree. Cleared forest land is used for plantations of pines, gums and other trees. Some species, such as *Pinus radiata*, make such rapid growth that the timber is of poor quality. The mountainous character renders the land of little value for agriculture.

WARM TEMPERATE FOREST

This is never at all an extensive type. It is found as patches in sheltered areas on south and south-east facing slopes and on the sides of river ravines in the central and midland parts of Natal and the south-east part of the Cape Province. Forest rarely occurs except at low altitudes and not very far from the sea. In Natal there are forest patches of this kind as high as 5,000 feet (1,524 m.), but these are rare; generally it is confined to low levels, in the southern portions not over 2,000 feet (610 m.). Forest only occurs in frost-free areas with moderate average temperatures. Temperatures are higher than in the Temperate Forest. This forest is confined to regions of high rainfall, 30–40 inches (76–100 cm.) or more, of which

about 70–75 per cent. falls in summer. The drought of the winter is not severe; forest is only found where there is some mitigating factor such as mist, or protection from evaporation.

Both geographically and in its development this forest is very closely associated with the Temperate Savanna type of vegetation. So close, indeed, is the relationship that separation is only made for the convenience of arrangement. The discussion of the development and utilisation (pp. 128–32) is based on the two together.

Three kinds of community are grouped together under this type:—

1. Warm Temperate Forest proper.
2. Scrub.
3. Succulent Scrub.

Warm Temperate Forest proper.—This exhibits a considerable range in complexity of structure in different parts of its region of occurrence. All stages of transition can be traced, however, from one to another. The more complex forms occur in the warmer northern parts, the simpler ones in the south. For example, in the midland region of Natal the forest is a many-layered community that shows some features in common with the Sub-tropical Forest. There are two layers of trees, shrubs and herbs below. Lianes are abundant, though not very numerous in species.

Herbaceous climbers are much more abundant than woody ones. The lianes do not bind the whole canopy together. Palms and the larger monocotyledons, which form such a characteristic feature of the Sub-tropical Forest, are here absent or are confined to streamsides. Epiphytes are not very abundant.

The forest appears evergreen, but there is an appreciable percentage of deciduous trees and many deciduous shrubs. The leaf form is rather varied; the small, oval, polished leaf is the commonest, but occurs along with larger thinner ones, and compound leaves are frequent. Many of the shrubs have quite thin leaves and spines are common. A considerable variety of trees make up the canopy and no one is dominant: *Podocarpus* is generally represented but is not very abundant; *Olea* is occasional. The ground layer is composed of a variety of herbaceous plants, among which Acanthaceæ are often prominent. Ferns are not very abundant except in the wettest places.

In the cooler regions further south the forest is simpler in structure and has a distinctly drier aspect. The trees are less distinctly stratified and lianes are less frequent. The shrub layer may be very dense ; in it *Tecomaria capensis* and *Plumbago capensis* are often very prominent. The ground flora consists of herbs, including several geophytes, with grasses abundant where the light is not very much reduced. Where the soil is very shallow a less dense forest occurs : *Commiphora*, *Cussonia* and *Euphorbia grandidens* become abundant. Shrubs are absent or much less continuous as a layer.

Forest communities, in which tree Euphorbias take a prominent part, are of common occurrence along the south coastal strip between East London and the Keiskama River.

Scrub.—Every stage of transition can be found between such simple, one-layered forests of the drier parts and less regular tree and bush communities that may be classed as " scrub." These are found where the rainfall is less than 25 inches (63 cm.) but the other conditions are suited to forest. On shallow soils, *Euphorbia grandidens* forms open or partly open communities. Elsewhere a mixed and varied one composed of trees and bushes is found. The shrub layer may be very dense : *Plumbago capensis* is exceedingly abundant wherever light penetrates. In these shrub communities deciduous species are not prominent, the great majority of the woody plants having rather polished evergreen leaves. The density and complexity of the community varies very much in accordance with the local conditions.

Succulent Scrub.—This name is applied to a community of bushes, sometimes with occasional trees or tree groups, which is found on the southern coastal belt where the rainfall is less than 20–25 inches (50–63 cm.), but where frost is absent. It is especially well developed in the country west of the Keiskama River, along the lower course of the Great Fish River and on the low ground south of the hills in the vicinity of Uitenhage.

The community varies from a tall bush with occasional trees, to a low scrub only 4–5 feet (1·2–1·5 m.) high. It is not often quite open but in all cases the bush layer is discontinuous. Bush clumps are common, but in the drier parts the community is open. An exceedingly characteristic feature is the presence in considerable abundance of larger succulent plants, among which Euphorbias,

Aloes and *Portulacaria* are very common. Along with these are numbers of shrubby plants, some of which are common in the drier parts of the forest, others characteristic of more open places. A large proportion are spinous, and this spiny character is emphasised by an abundance of *Asparagus*, which climbs through and over the bushes. Small climbers are everywhere abundant. Most of the shrubs are evergreen and the majority have rather small leaves which are hard and dull. Woody plants with polished leaves are not frequent. Several have hairy leaves. The general aspect of this scrub is dry and xerophilous, which is emphasised by the abundance of the succulents.

The ground flora varies; in the moister parts grasses are abundant; in the drier ones low undershrubs with small succulents are predominant. Annuals are very abundant. A few shade plants occur under the bushes. The composition and density of this scrub varies very considerably and every stage of transition can be traced from the drier types of forest scrub to an open low community in which succulents predominate. In the driest parts *Euphorbia* spp. and *Aloe ferox*, a tall-stemmed aloe with prickly leaves, form an open upper layer over a lower layer of small undershrubs. Such facies form the transition between this scrub and the open communities of arid parts. Transitions also occur between these open communities and the *Acacia-Pentzia* community of the Temperate Savanna. For example, in the country between the Winterberg Mountains and the Great Fish River in the Cape, there are many communities in which *Acacia karroo* and *Aloe ferox* share prominence in the upper layer, occurring either together or in alternating patches.

In spite of the rather wide range in details of structure, this Succulent Scrub forms a definite vegetation unit which is characteristic of a rather arid but frost-free climate. It is one that has long been recognised though it has not been studied in any detail: in 1872 it was separated by Grisebach as "Fish River Scrub." Sim has aptly described it as "the result of a Karroo climate on a forest vegetation." Certainly every gradation can be traced between the typical Warm Temperate Forest and this Succulent Scrub.

The modifications, development and succession, and the utilisation of the Warm Temperate Forest are dealt with along with those of the Temperate Savanna and are discussed under that heading.

SUB-TROPICAL FOREST

Along the low-lying coastal strip on the east coast there are conditions more distinctly tropical than in most parts of the Union. The rainfall is high and there is no prolonged dry season. The temperature is uniformly high. These conditions are confined to a narrow belt that extends from the northern boundary of the country to about the level of Port Shepstone. This belt is nowhere over 1,000 feet (305 m.) in height and except in the extreme north is not more than a few miles wide. Much of it is composed of beach-deposited sand and the rest of soft, rather sandy, rocks yielding deep soils.

The vegetation is of a tropical character and represents a southward extension of the type that is developed much more completely further north in Portuguese East Africa. The characteristic community is forest. For purposes of description four divisions are made, though these are not of equal importance :—

1. Forest.
2. Sand Forest.
3. Mangrove Swamps.
4. *Barringtonia* Community.

Forest.—This is undoubtedly a climax. Though these forests do not attain a great height they are dense and complex in structure. In their full development they are many layered, with two strata of trees, shrubs and herbaceous plants below. The canopy is bound together and often rendered very dense by large numbers of lianes which are always present and form a characteristic feature. Both woody and herbaceous climbers are present. Epiphytes occur, but are not very abundant either individually or in species.

The trees are evergreen or almost so, with leaves of medium to large size, and compound leaves are very common. The texture of the leaves is varied. Several trees are evergreen in these forests, though deciduous when growing in less favourable conditions. The commonest trees are *Albizzia gummifera, Protorhus longifolia, Sclerocarya caffra, Trichilia emetica* and *Ficus* spp. A characteristic feature of these forests is the presence, often in considerable numbers, of large monocotyledons, such as the palms *Phœnix reclinata, Hyphœne crinita,* also *Baphia racemosa, Dracæna hookeriana, Strelitzia augusta* and others. Locally these plants are very abundant, and in consequence the term " Palm Belt " has been applied to the vegetation.

Both in structure, leaf form and in floristic composition this forest shows close relationships to the forests of the tropics. It differs in many ways from the more temperate forests, though there are a number of species in common. The large, thin leaves, the palms, and the great mass of lianes together make a definite means of separation of this type. The forest exhibits changes in composition and structure in different parts of the coast belt and on different kinds of soil.

Sand Forest.—Where forest is developed on sand recently deposited by the sea it shows distinctive features. It is simpler in structure; there is only one layer of trees, which form a dense canopy of rather definite uniform height. The upper surface is very even and often so smooth that it gives no indication of inequalities of the ground surface. This smooth exterior form and simpler structure are due to exposure to sea winds. The Sand Forest is composed of a considerable variety of trees which have a smaller average leaf size than those in more sheltered localities. Lianes are exceedingly abundant and bind the canopy into a dense tangle of branches which allows little light to penetrate. In consequence the undergrowth is often sparse or lacking except in the more open spots where *Strelitzia*, *Hyphaene* and a number of shrubs are abundant. Every stage of transition between this Sand Forest and the more typical Sub-tropical Forest can be found.

Mangrove Swamps.—Mangroves certainly do not form a stable community, but are so characteristic that they justify individual treatment. Here they are confined to estuaries and lagoons and vary in extent according to local conditions. The mangroves found are *Avicennia officinalis*, *Rhizophora mucronata* and *Bruguiera gymnorrhiza*. They may form dense forest-like groves.

Other plants associated with mangroves are not numerous either in species or as individuals. In the denser parts no others may be found. The most common plants in the community are *Chenolea diffusa*, *Triglochin* sp., *Salicornia* sp., *Acrostichum aureum* and a few others.

Mangroves are frequently the pioneer plants in the colonisation of tidal mud. On the other hand, they may invade and finally dominate mud already occupied by *Salicornia*. Where the mud is soft and occurs in protected estuaries the mangroves are the pioneers: *Salicornia* colonises firmer stretches of flats that become

partly hardened by exposure. Mangrove communities have been so often and so fully described that no elaboration is needed. The community in this country is of small extent and presents no unusual features that call for further description.

***Barringtonia* Community.**—This is also a community of limited extent occurring on damp littoral habitats on sandy ground not inundated by the tides. It is a fringing community, exceedingly characteristic of more tropical coasts. The most abundant tree is *Barringtonia racemosa*, with which are associated *Syzygium cordatum*, *Hibiscus tiliaceus*, and of herbs *Ipomœa* spp., etc. The *Barringtonia* community is often, but not necessarily, associated with the Mangrove Swamps, frequently occurring on the drier ground at their inland margin. But it is also found along the sides of estuaries where no mangroves occur at all. The details of the relationship of these communities, either Mangrove Swamp or the *Barringtonia* community, both of which are essentially unstable and transitory, to those of dry land, and especially to the forest, require further investigation. The close association of these essentially tropical communities with this kind of forest is an additional reason for the separation of it from those of more temperate regions.

Development and Modifications.—The forest which is the climax of this type at the present time exists in rather small patches and strips and is seldom extensive. The limitation of forest is due to the clearing of land, either partial or complete, for cultivation or other purposes, which has gone on for centuries. Native cultivation affected small areas, but owing to its transitory nature (shifting cultivation) the number of these, and therefore the total area involved, was great. The destruction brought about in this way is less complete than where Europeans are active, as the abandoned native plots are allowed to regenerate. On them various stages of re-growth can be traced. In recent years destruction has been rapid ; not only have large tracts been cleared for sugar plantations, but the parts around have been cut to supply the demands for fuel for the sugar mills. This has been carried to such an extent that in some regions it is now very difficult to find any examples of untouched forest.

The primary succession can be made out on coastal sandhills. In such places a fairly complete series is traceable. The pioneer is *Ipomœa biloba*, which forms at first almost pure communities, and

may also follow and invade strand communities where deposition is slower. As soon as this plant stabilises the sand, competition commences and the pioneer is finally ousted. The first invaders are herbaceous plants, but are soon followed by shrubs which build up a dense community. From this shrub community the beginnings of forest commence. Where forest has been opened up by wood cutting, *Hyphæne crinita* and *Strelitzia augusta* often become exceedingly abundant, and one or other may attain dominance. Patches with these plants in great numbers are common and seem always secondary. *Strelitzia*, however, may be very abundant or even dominant on very shallow or unstable soils which are quite undisturbed.

On abandoned cleared land the first woody plants are bushes of a rather drought-resistant type, many of which are spinous. As these become closer, others with larger and thinner leaves become more prominent. Exactly similar types of bush communities occur as fringing zones round some of the forest patches. The earlier type occurs further out. The palms become abundant in the later and more complex types of scrub, and it is from such that forest could develop. Some scrub areas are the result of the cutting out of all the trees and larger plants from a forest.

Utilisation.—Though its area is small this Sub-tropical Forest has been much exploited for cultivation. The soils are deep and, when the forest is first cleared, very fertile.

Native cultivation is mainly devoted to maize, Kaffir corn and food crops. The chief crops grown by Europeans here are sugar, tea, cotton, and various tropical and sub-tropical fruits such as bananas, pawpaws, mangoes, pineapples and avocado pears (*Persea gratissima*). Sugar is much the most important industry. No natural resources are made use of.

Afforestation.—Tree planting has not been carried out at all extensively. The land has been in demand for cultivation and timber has been abundant. Several areas have now been made forest reserves. Some of these are for protection of the fast disappearing forest, others are being planted. Such plantations as have been established earn an income from the sale of thinnings as fuel for sugar mills. The species planted here are *Pinus palustris*, *P. tæda*, and several kinds of *Eucalyptus*. Other trees have been planted experimentally, but not in quantity.

MONTANE FOREST

The vegetation grouped under this heading occurs on the slopes of the higher mountain ranges in the northern and north-eastern parts of the Transvaal. The characteristic climax vegetation is forest, which is found in ravines and also, where conditions are favourable, covering whole hillsides. The forests are most extensive on the east-facing slopes of the Drakensberg escarpment, but also occur on the ranges further towards the interior, extending as far as the Zoutpansberg. Forests are only extensive on east- and south-facing slopes. They occur on north- and west-facing ones in the eastern parts but not further west. On such exposures, however, the forest is only in ravines or just below cliffs. It is noticeable that on the ranges that extend westwards towards Pietersburg the quantity of forest on the northern slopes rapidly decreases from east to west. At the western end of the range there are none on the north slopes. On the Zoutpansberg, too, forest is confined to the southern slopes.

The forests are found in a definite belt at altitudes of 4,700 feet (1,432 m.) and over. They come lower in the east than further west. The upper limits are dependent on the heights of the mountains. This forest belt has a relatively low temperature ; much lower and with much smaller fluctuations, both seasonal and daily, than occur in the adjacent vegetation below or above. At the stations where temperatures are recorded, which are of course in the open, frosts are of frequent occurrence in winter. It is more than doubtful whether frost ever occurs in the forests themselves. The rainfall in the forest belt is high, not less than 55-60 inches (139–152 cm.), and often more. The belt receives as high a rainfall as any part of the country. The rain is largely concentrated in summer ; only about 15–20 per cent. of the total falls in the winter six months. The dry period is, however, moderated by the frequent presence of mists. These mists are so common that this kind of forest has been called " Mist Belt Forest." The mists often form only in the early morning and persist for quite a short time, but even so they produce an appreciable quantity of moisture. After such a morning mist, while the surrounding vegetation is quite dry, the interior of a forest is dripping wet. Even on a warm day the forest feels damp and cool. Inside there is a relative humidity that is 10 to 15 per cent. higher than that outside.

Most of the forests are found on rather steep slopes, and the soils are most often shallow and immature. Where deep soils are present they are red or red-brown in colour and very different from the podsol-like soils of the Temperate Forest. These forests are of a distinctly moist character; they are evergreen with few deciduous trees, which occur only where the full development is not reached. The forest is mixed without any single dominant species. The main canopy is far from uniform in height and the exterior is irregular. There are two strata of trees, but they are not at all sharply separated from one another.

The average leaf size is distinctly larger than that of the Temperate Forest. Many of the leaves have a polished surface, but this character is not at all universal. There is much variation in thickness; some are firm, others much thinner. The larger, often thinner, and less polished leaves give these forests a greener and less dark appearance than is the case with the Temperate Forest.

Below the trees are shrubs, the distribution of which is variable; in places they form a dense layer, elsewhere they are thinly scattered, or locally absent. Many of the shrubs have quite thin leaves; none have very large ones. The lower strata are composed of herbs, undershrubs and many small plants. A number of these have leaves of very thin texture which wilt easily when gathered. Lianes occur, both woody and herbaceous, but are only locally abundant. Epiphytes are, however, common: the upper branches of the trees are festooned by lichens; the stems and lower branches covered by mosses. Vascular epiphytes are not infrequent: ferns, *Lycopodium*, *Peperomia*, *Streptocarpus*, orchids and others.

These forests are not uniform in structure or composition, but so little study has been devoted to them that it is not possible to separate the different communities except on the most general features.

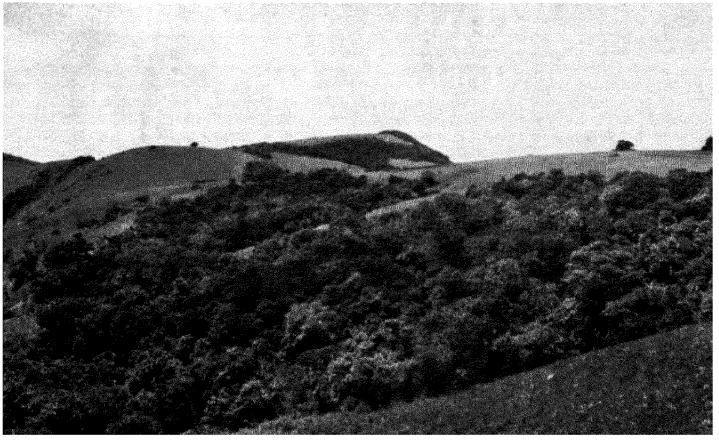
The following divisions can be made:—

1. Forest (including several habitat divisions).
2. Scrub.
3. *Albizzia* Woodland.

The two last are not real climax communities, but stages that become stable under unfavourable local conditions.

Forest.—The typical forest is made up of a variety of trees whose

PHOT 4 Partially exploited TEMPERATE FOREST at Deepwalls, nr. Knysna, Cape Province. The large trees are *Podocarpus falcata* (right centre and left), *Apodytes dimidiata* and *Olinia cymosa*. In foreground *Clutia pulchella*, *Helichrysum petiolatum*, *Pteridium aquilinum*, etc.



PHOT. 5.—Patches of MONTANE FOREST on upper slopes of mountains surrounded by grassland at Woodbush, Transvaal. Relict trees and bushes; the paler bushes in front mark the marginal zone. (Photo: I. B. Pole Evans.)

[*Facing p.* 116.

rounded crowns give a smoothly undulating upper surface to the canopy. The largest trees may reach a height of 70–100 feet (21–30 m.). Many of the trees show a striking development of buttress roots. The ground vegetation varies in accordance with the degree of shading, depth and moisture of the soil, and other factors. Where light is much reduced small plants make up the ground flora; ferns are numerous and often dominant. Where more light penetrates a strong growth of tall herbs, many of which have large very thin leaves, is found. *Hypoestis* sp., *Impatiens capensis*, *Piper capense*, *Plectranthus* sp., and a number of larger ferns are especially common. *Selaginella kraussii*, a soft moss-like creeping plant, is everywhere abundant.

In the damper ravines and along streamsides several trees occur which are not found in the drier parts. The canopy here is dense and much more uniform in height. Shrubs are less abundant except where light can penetrate. The undergrowth is largely made up of ferns; the tree fern *Cyathea dregei* is often very abundant.

On shallow soils and the more exposed ridges a drier type of forest is found which often has a single layer of trees not more than 30–40 feet (10–12 m.) high. Many of the common trees of the forest are absent and their place is taken by species demanding less moisture, which include some that are deciduous or semi-deciduous. Shrubs are very abundant so that the amount of light reaching the ground is small, and a sparse undergrowth occurs in which the grass, *Oplismenus africanus*, and the ferns which need less moisture are the most abundant. Lianes and epiphytes are here much less abundant.

At the uppermost levels reached by the forest, 5,000 feet (1,524 m.) or over, a change in structure and composition occurs. Many of the plants with larger thinner leaves disappear, and several trees are present that do not occur lower down; the most important of these is *Podocarpus*. The shrub layer at these higher levels is often very dense and composed of plants with rather small leaves. Lianes are scarce and epiphytes absent except for very abundant mosses and lichens. The ground flora is low growing and commonly sparse; ferns, *Selaginella* and *Lycopodium* are the principal constituents.

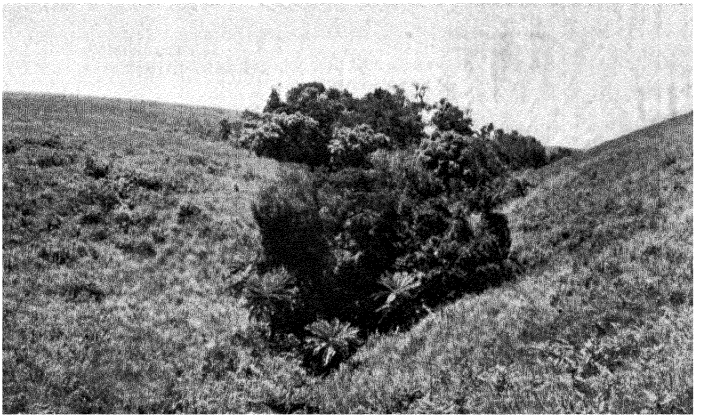
Scrub.—Montane Scrub communities composed of bushes without a continuous tree stratum, occur as a marginal zone, more especially at the upper limits on exposed ridges, and other places where condi-

tions do not admit of complete development. Every grade can be found between true forest and bush communities not more than 6–8 feet (2–2·5 m. high). In these scrub communities both structure and composition vary greatly from place to place: in general, the more hardy and smaller leaved plants are abundant. A large number of light-demanding shrubs not found in the forest are characteristic of the scrub communities.

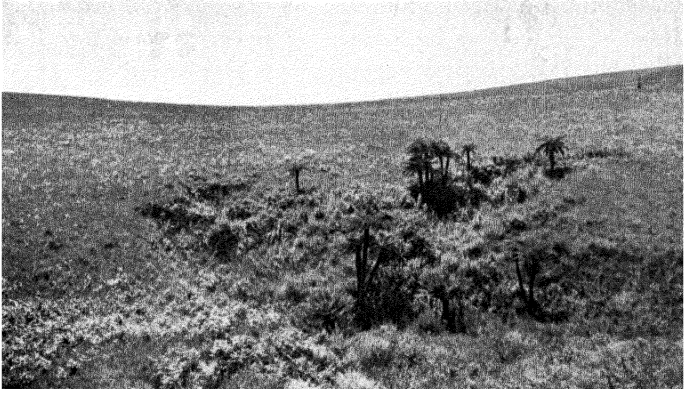
***Albizzia* Woodland.**—Though at first sight very different, both in structure and plant habit, this is a community closely related to the forest. It is most characteristically found at rather lower altitudes where the rainfall and mists are less. The structure is much simpler: there is a single tree layer of uniform height, 20–30 feet (6–9 m.). The trees are deciduous, the commonest being *Albizzia gummifera*, which may be a pure dominant or in association with *Acacia ataxacantha* and a few other species. Evergreen trees are found only in the moister places. The canopy is not a dense one except by streams, where the evergreens become dominant. Below the trees is a dense shrub layer, included in which are a number of plants characteristic of the forest or the forest margin, together with species demanding more light. A considerable percentage of these shrubs are spine-bearing. Lianes and scramblers are abundant and often bind the shrub layer into an impenetrable tangle: *Rhoicissus* is confined to stream channels, but *Clematis*, *Pterolobium*, *Rubus pinnatus* and many herbaceous climbers or scramblers are very common. The ground vegetation is very much like that of the drier parts of the forest: *Moræa iridioides*, with white flowers borne on stems 1–2 feet high, *Oplismenus africanus*, and a number of ferns are especially common.

In the ravines and sheltered places various transitions between this deciduous woodland and more characteristic forest can be traced.

Modifications.—The forests that exist cover only a part of the area that was evidently at one time forest-clad. Felling and fire have been responsible for the greatest amount of destruction. Clearing for cultivation has also taken place. Much of the land from which forest has been removed is now occupied by grassland, by various scrub communities, or has been made use of for plantations. Evidence of the former extent of the forest is not difficult to find. The forest patches themselves often have irregular outlines that do



PHOT. 6. -Progressive destruction of MONTANE FOREST. A relict patch in a kloof at Woodbush (Transvaal) left after destruction by cutting, burning and grazing. Tall grass with *Pteridium* and several bushes mark a beginning of possible regeneration. (Photo: I. B. Pole Evans.)



PHOT. 7. -Progressive destruction of MONTANE FOREST. Final phase, Haenertsberg, Transvaal. The trees have disappeared; tree ferns (*Cyathea*) persist by the stream, with other ferns and some shade-loving species. Grassland with *Pteridium* around. (Photo: I. B. Pole Evans.)

[*Facing p.* 118.

not correspond with any natural boundaries, and small groups of trees or even isolated individuals occur between in grassland or scrub. The intervening vegetation often contains forest plants that persist, at any rate for a time. Tree ferns, for example, are often seen along streamsides in the open. These exposed tree ferns show signs of frost damage that are not apparent in those in the forest.

In addition to this complete destruction, many of the forests have been altered by the cutting out of the larger trees. The demand for timber for the mines, both local and those of the Rand, has caused a great deal of indiscriminate cutting. In some cases this has resulted in the establishment of dense scrub communities in which very little light penetrates to the ground. In such scrub communities many species usually confined to forest margins become general and abundant. It is very common to find that in these disturbed forest areas the larger leaved moisture-demanding plants become scarce or disappear altogether. The vegetation as a whole has a drier aspect.

Development and Succession.—There is a complete lack of detailed work on these forests, and such data as are available on their development are based upon comparable observations and the results must be recognised as suggestions rather than ascertained facts.

Where forest is totally destroyed the ground becomes invaded by Montane Grassland which covers the higher areas and the more exposed ridges. Such invading grassland, in the absence of severe grazing, differs from the typical community in being much mixed with plants generally characteristic of sheltered places. These are either herbaceous, *e.g.*, *Pteridium aquilinum*, or undershrubs. Under favourable conditions, with absence of successive fires or of grazing, the shrubby plants increase and finally build up a community from which the tufted grasses are excluded. Such communities are of varied composition. In the earlier phases the constituent plants do not have at all the leaf characteristics of the forest. Between and among the shrubs are tall growing grasses. The cover provided by the shrubs introduces conditions suitable for the more tolerant of the evergreen shrubs. If undisturbed these gradually increase, and ultimately forest scrub gets established and succession to forest can follow. In other cases *Acacia*, *Albizzia* and others become established in the early shrub community and an *Albizzia* woodland results. From this forest can in time regenerate.

When grazing occurs the development is often checked in the earlier stages or even prevented, and grassland is established. On slopes it is not infrequent to find an alternation of grassland, shrub communities, and occasional scrub or *Albizzia* woodland. Such areas are much favoured by the natives for pasturage and cultivation. The *Albizzia* woodland, though certainly often a regeneration or developmental phase of the forest, can exist in conditions in which the reduction of rainfall and mist would not permit of true forest at all.

Utilisation.—The mountainous character of the land renders it of small value for cultivation. The forests themselves have been used as a source of timber, though now plantations provide a more easily available supply. Control of the forests that remain has stopped the rapid and indiscriminate felling that took place at one time.

Land cleared of forest is utilised as grazing land for sheep and for the not very extensive native cultivation. At the present time much of the land has been taken over by the Forest Department and is being used for plantations. Private plantations are on quite a small scale. The species planted are chiefly *Pinus patula*, *P. tæda*, *Eucalyptus saligna* and other gums. Wattles (*Acacia mollissima* and *A. decurrens*) are also planted, but are liable to frost damage in the early stages. Of the trees *Pinus patula* is the most important at the higher levels, *Eucalyptus* lower down.

GENERAL SUMMARY OF FOREST

The four types of forest are in many features similar to one another, and all possess structural and floristic characters in common. Nevertheless they are readily distinguished. The Sub-tropical Forest is the most complex, with its great abundance of lianes, often large leaves and frequency of palms. The Warm Temperate Forest is distinguished by the number of deciduous trees and relative scarcity of ferns. It is the driest type. The Temperate Forest is distinctive owing to the exceedingly uniform, dark-coloured, small, polished leaves. The contrast in appearance and character of the canopy between this and either the Warm Temperate or Montane Forest is very striking, a contrast that is much more evident in the field than might appear from the descriptions. The external surface of the Temperate Forest is much more irregular than in any of the others. The Sub-tropical Forest is undoubtedly a southern exten-

sion of the vegetation of the tropical coastal belt. The Montane Forest, in structure, habitat conditions and composition, is most nearly allied to the "Mountain Forest" of Rhodesia and the Montane Rain Forests of the mountains of central Africa.

Though the different types are linked by forests of intermediate character that exist under intermediate conditions, they certainly are to be regarded as distinct types developed under distinctive habitat conditions. They have quite distinctive relationships to other kinds of vegetation.

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See also Nos. (19), (20), (21) in References to Chap. IV; and (1), (9) (Chap. V).

CHAPTER VII

SAVANNA VEGETATION

GENERAL

In the more tropical regions, where the rainfall is seasonal with a pronounced dry period, there is developed a very characteristic vegetation which, in its main structural features, is uniform over very wide stretches of country. This is a savanna type with an upper stratum of trees most commonly of rather low stature and not often contiguous. The trees stand in a grass-dominated undergrowth which dries up and is dormant during the dry season. The numbers of the trees vary enormously, from conditions approaching forest at the one extreme to grasslands with few scattered trees at the other. The trees are very commonly umbrella-shaped or have a flattened spreading crown. Most have a single stem bare of branches for some distance from the ground. Shrubs with many stems are not abundant. The great majority of the trees are deciduous, though the leafless period may be a very short one.

A feature of this vegetation is the presence of treeless grass-covered strips along flat valleys or drainage channels with little slope. These grass stretches, or " dambos," occur in places where the soil is liable to become waterlogged in the wet season. Such dambos experience much greater fluctuations of temperature, both daily and seasonal, than occur in the tree-covered portions. For this reason a dambo, once formed, is not readily occupied by trees even where the water conditions would permit, though they might come back eventually.

Throughout this savanna vegetation large termitaria are a conspicuous feature: some of them attain a very large size. These "ant-hills" often bear a more luxuriant growth of woody plants than the surrounding soil. Some species appear to be confined to the ant-hills; among these are some evergreen trees. Clumps of trees and bushes in which the canopy is quite continuous are often formed on and around these sites, although the surrounding vegetation is an open savanna.

This savanna vegetation is the most widespread type on the plateau land of central and south-central Africa. Tree Savanna is the dominant type from the central part of the Transvaal northwards. It covers most of Southern and Northern Rhodesia, much of Tanganyika and Kenya, and extends into Uganda and the Sudan. It is almost unbroken over vast stretches of the country. A vegetation that covers so wide an area of course exhibits great diversity in detail from place to place, but not only are the main structural features the same throughout, the essential characters of the climate are also the same. The rainfall is definitely concentrated in summer, with the winter dry; the temperature is relatively high though tempered by altitude.

The pronounced dry season, during which the grass dries up and the aerial parts die, provides conditions exceedingly suitable to fire. Throughout the whole extent of this vegetation grass fires in the dry season are very common. Such burnings have certainly been occurring for a very long time. These very frequent fires are undoubtedly responsible for some of the characteristics of the vegetation. The very open tree cover, the frequently developed umbrella shape with the stem bare of branches below, and the absence of bushes and often of young trees as well, are all attributable to this periodic burning. The fires are usually of human origin, some intentional, others accidental, but they can start from natural causes. Whatever their origin they have become such a common occurrence that they must be reckoned as a regular part of the habitat conditions that determine the structure and development of the vegetation.

The southern margin of this widespread savanna vegetation, characteristic of vast areas in south-central Africa, extends to within the boundaries of the Union of South Africa, where it occupies the warmer parts of the summer rainfall region. It covers the whole of the northern portions and extends along the east coast to the extremity of the continent. Four types of savanna vegetation can be recognised in the country: Temperate Savanna in the southeast forms the southernmost extension; Low Veld and Bush Veld occupy the northern, more tropical, parts and are the representatives most closely allied to the wide stretches of this vegetation in central Africa; Bush Savanna is a type developed under semi-arid climatic conditions.

TEMPERATE SAVANNA

This vegetation occupies the greater part of the coastal belt and foothills in the south-eastern parts of the country. It covers the midland region of Natal and most of the south-eastern Cape. It is a vegetation with rather sharply limited conditions of existence. At higher altitudes it is replaced by grasslands, in the west it is limited by decreasing rainfall, and along the south coast by change in the rainfall distribution. In Natal the upper boundary is about 4,000 feet (1,220 m.), the hills extending above this height being covered by grassland. This vegetation extends along valleys and lower levels as far north as Colenso and Ladysmith. In the south it occupies the country between the coast and the Amatola Mountains, Winterberg and Zuurberg, with a northward extension through Tarkastadt, along the foothills of the Stormberg to the vicinity of Molteno. Westwards it is bounded by the line of 12 inches (30 cm.) rainfall. On the south coast it extends to the neighbourhood of Port Elizabeth.

The whole region has a rainfall of which 70 to 75 per cent. falls in the summer months. The total rainfall varies from 40 inches (100 cm.) in parts of Natal, to as little as 12–15 inches (30–38 cm.). Temperatures are moderate, with a considerable range, though less, and with less extremes of cold, than the adjoining grasslands. Frosts occur in winter in all the inland parts but are not at all severe.

The vegetation is an open bush or very small Tree Savanna, with an undergrowth of grass or low undershrubs. The name Temperate Savanna is applied to distinguish the vegetation from the more complex savannas in the more tropical regions. This vegetation is geographically and in structure and composition separate from the Tree Savanna, though certainly allied to it.

The Temperate Savanna is divisible into three sections, namely :

1. *Acacia* Grassland.
2. Bush Clump Community.
3. *Acacia-Pentzia* Community.

Of these the first is much the most extensive and may be looked upon as the typical one.

***Acacia* Grassland.**—This kind of vegetation covers the whole range of the type with the exception of the driest portions. While

there are great variations in the floristic composition in different parts, there is a striking degree of constancy in the general structure and physiognomy. The ground layer is closed and dominated by close-growing, rather low, grasses. The upper stratum is discontinuous, and made up of bushes, or less often small trees, of which Acacias are much the most common. These bushes may be quite small, 3–4 feet (0·9–1·4 m.), or at times larger, reaching as much as 6, or even occasionally 10 feet (2–3 m.). The bushes are most often quite separate and scattered at rather wide intervals. In some of the more luxuriant forms at low levels near the coast they may be almost continuous. All intermediate conditions exist. The bushes may be of even height, but more often larger and smaller ones occur in association. They are most commonly rather flat-topped, and, while characteristically single-stemmed, may branch from near the ground level.

The species vary in different parts but all have the same form, deciduous, spinous, flat-topped bushes or small trees. *Acacia karroo* is the commonest and, in the drier parts, the only species: it is a deciduous bush or small tree with long, straight thorns. *A. caffra* is common in the south-east Cape, and other species occur in Natal. Other bushes may occur with the Acacias, though for miles of country these are the only woody plants. From the abundance of the spiny Acacias this kind of vegetation is often referred to as "Thornveld," but the term is by no means restricted to this community; it is applied to any vegetation in which Acacias are predominant. Bushes that are commonly associated with *Acacia* are *Zizyphus mucronatus*, a bush with hooked thorns and ovate leaves, *Gymnosporia buxifolia*, another spinous bush, *Euclea* sp., *Royena* spp., *Cussonia* sp., and others. *Aloe* spp. occur locally. *A. marlothii* is confined to rocky places in the northernmost parts.

The field layer is generally closed and dominated by grasses: *Themeda triandra*, and especially the glaucous form of this species, is the most general dominant, though other grasses occur and locally replace it. The taller grasses, *Andropogon*, *Hyparrhenia* and others are mainly in the northern parts. *Eragrostis* is common and often dominant in the south. Most often the field layer is low-growing. Where luxuriant it may attain 3 feet (1 m.) at the flowering period, but generally it is lower. Other plants occur associated with the grasses, but do not represent more than a small percentage of the

ground cover in the drier portions. Annuals are not at all abundant.

The size and abundance of the woody plants give a good indication of the habitat conditions. In the drier and cooler regions the bushes are both small and scattered. In the north they are taller and more tree-like, but no less open.

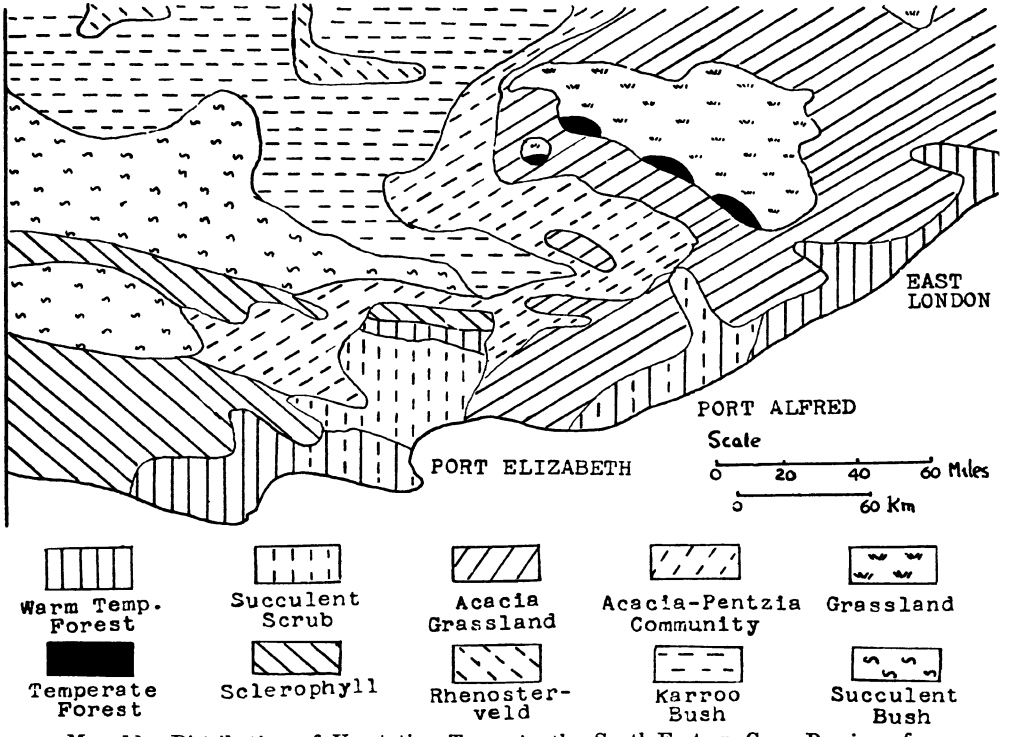
Bush Clump Community.—This is very closely allied to the *Acacia* Grassland and connected to it by every stage of transition, being really in the nature of a local development, and scarcely to be separated geographically. When fully developed the woody plants build up groups or patches with a continuous canopy. Such patches may be as much as 50–100 yards (45–90 m.) across, though generally much less. The patches or clumps are separated from one another by open stretches of grass or grass with scattered bushes.

A more varied flora is found here, including a number of evergreen trees or bushes, and the Acacias may cease to be dominant: they are still present but may be restricted to the marginal parts of the clumps where these become dense. Among the abundant plants in these clumps are: *Commiphora*, *Cussonia*, *Harpephyllum*, *Gymnosporia*, *Ekebergia*, *Royena*, *Zizyphus*, with many of the plants of the drier parts of the Warm Temperate Forests. *Aloe ferox* and tree-forming Euphorbias occur in this community on rocky soils, and the cycad *Encephalartos* on steep slopes.

The field layer varies with the degree of cover: between the clumps tall grasses are often dominant. In the denser places grasses are infrequent, and such plants as *Hæmanthus*, *Sansevieria* and others become abundant.

***Acacia-Pentzia* Community.**—This is a closely allied though distinct type that is found in regions of less rainfall than those occupied by *Acacia* Grassland. It is best developed where the precipitation is 12–15 inches (30–38 cm.), and forms a transition zone between the other communities of the Temperate Savanna and the open communities of more arid regions. Though much less extensive than the *Acacia* Grassland, it covers quite large stretches along the inland border of the area of the type.

The most apparent differentiating feature here is in the field layer, which is not dominated by grasses and is not continuous: it is made up of low undershrubs. *Pentzia* spp., *Chrysocoma tenuifolia*, *Selago* sp., and others, are the most abundant and build an open



MAP 12.—Distribution of Vegetation Types in the South-Eastern Cape Province from Humansdorp to the mouth of the Kei River.

layer. *Pentzia* and *Chrysocoma* may be associated together or may alternate in patches. This field layer may be almost closed or the little bushes may not cover more than 60 per cent. of the ground. Grasses are either quite absent or found only as temporary constituents after suitable quantities of rain. Annuals are abundant.

The bushes are separate and scattered at intervals from one another, very rarely contiguous, and never forming clumps. They are of small size, not often exceeding 6 feet (2 m.). *Acacia karroo* is generally the dominant, and for miles the only shrubby plant except along stream channels. *Euclea, Royena, Rhus, Aitonia, Aloe ferox* and some others occur locally.

This *Acacia-Pentzia* community passes gradually into the typical *Acacia* Grassland, and all stages can be traced between them with mixed transitional field layers. The community is to be looked upon as a development of the Temperate Savanna under almost limiting conditions of moisture.

Development and Succession.—In this and the following sections the Warm Temperate Forest and Temperate Savanna are taken together. They are so closely related, both geographically and in other ways to be pointed out, that the separation that has been made in the descriptions is only justified on the grounds of convenience of arrangement (see p. 108). The Warm Temperate Forest occupies small localised patches in the wider area of the Temperate Savanna (Map 12). In the following description the whole region is regarded as one unit.

Of the various kinds of community in these two types the Warm Temperate Forest is the most complex and one that, without doubt, is a climax. Forest is, however, restricted to a limited part of the region where the supplies of moisture are large and there are no frosts. Within such limits a succession can be traced from pure grassland, through grassland with Acacias, to scrub, and finally forest. The series is quite easily made out in parts of the coast belt. But this does not mean that the forest is to be looked upon as the climax over the whole area. Over much the largest part the climatic conditions, with moderate rainfall, a long dry season, and liability to frost, are definitely adverse to forest development. In these places *Acacia* Grassland, or in some cases the Bush Clump community, which develops from it, represent the highest stage that

can be attained. In other words, over the greater part of the region the *Acacia* Grassland type of community must be regarded as the natural climatic climax. This is the reason that underlies the separation of the two as distinct types in spite of the very close connections both in development and in distribution.

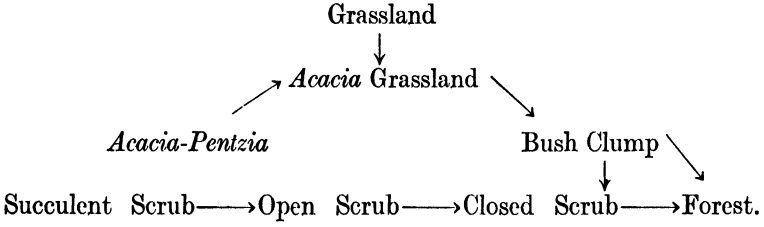
At higher altitudes the *Acacia* Grassland is extensive and quite stable, but nearer the coast, especially in Natal, the conditions are different. In the absence of disturbing factors, such as burning, and even more of grazing, development will proceed to a more closed community. The Acacias become more numerous and closer, and other shrubs or trees, many of which are evergreen, appear beneath them. There are accompanying changes in the ground flora, where the more tufted grasses become suppressed and shade-loving herbs appear. It is, however, very doubtful if the development would proceed beyond the condition of a Bush Clump community except under the most favourable conditions. In the last case, which is possible close to the coast, forest would ultimately develop. *Acacia* Grassland regularly occurs as a fringe round the forest patches and takes possession when forest is destroyed. *Encephalartos altensteinii*, a typical cycad, is not uncommon in these fringing zones of *Acacia* Grassland.

Over much of the frost-free coastal belt the more sheltered slopes and valleys are occupied by a mixed vegetation consisting of grass with *Acacia* bushes, sometimes almost continuous, alternating with thickets made up of a variety of bushes, largely evergreen. Some patches of forest, usually small, also occur in the most sheltered places. Every stage of gradation can be found between the typical *Acacia* Grassland and forest.

To recapitulate, *Acacia* Grassland is the true climax over the greater part of this region, either as a community with scattered bushes or, in moister places, with bush clumps and a greater variety of species. The possibility of further development that culminates in the Warm Temperate Forest is confined to the moister frost-free parts near the coast. Development that will culminate in forest does not necessarily pass through the *Acacia* Grassland phase. In the frost-free belt a succession through Succulent Scrub takes place, evidences of which can be seen in many of the forest areas. In river gorges various stages of scrub, with or without prominent succulents, occur. These are often confined to shallow soils, with true forest on

deeper ones. In the drier climates on the south coast such stages, or even the Succulent Scrub itself, represent the final stage that can be attained.

The successional relationships of these communities are expressed diagrammatically in the scheme below. In this moisture increases from left to right, liability to frost from below upwards.



Modifications.—The area of Temperate Savanna supports a relatively large population, and has been occupied for a long time. A considerable concentration of natives is found, and since the settlement of the country by the Europeans this has been increased, though localised, by the demarcation of a number of native territories which fall within the area. These are the Transkei Territories, Pondoland, Tembuland and Griqualand East. Other parts of the region have been occupied by Europeans.

The large population that has occupied this region for some centuries has produced considerable alteration in the vegetation. It is not too much to say that, with the exception of the steep-sided river channels and the more mountainous parts, very little of this region is without some sign of modification. The degree of change has a close relation to the population. The most obvious signs of change are seen in the destruction and elimination of the trees and bushes. Forest has been destroyed, and large areas of the savanna converted to grassland. Such areas of secondary grassland are found most commonly in the more populated regions, but are common throughout; they form a zone round towns or villages, both European and native. The clearing and removal of the woody plants have been carried on from the earliest times and have been due originally to demands for timber for construction and for firewood, and later to improvement of pasture. Burning assists materially in the preservation of the secondary grasslands; cutting of the grass for hay is also an important factor, and for hay pastures clearance

is obviously necessary. The degree of alteration in the composition of these grasslands varies in accordance with the treatment they have received. While some of them show practically the same flora that occurs in the untouched vegetation and only differ in the removal of the woody plants, others show much more profound changes. In those parts where grazing has been carried on intensively the flora may be very much changed: the larger and taller grasses are destroyed and their place taken by low creeping species. There is frequently a zone around farms or native settlements which is covered by an open community of *Cynodon dactylon* (dogs-tooth grass, "fine kweek"), with various weeds, but no trace of the larger grasses. In extreme cases the grasses are wholly suppressed and the area becomes occupied by plants that are not eaten by the animals. These plants may be part of the original vegetation or less often invaders. An example is *Helichrysum argyrophyllum*, a prostrate undershrub with white woolly leaves, which becomes completely dominant on overgrazed areas. It is quite untouched by grazing animals, and owing to the size of the bushes it reaches real dominance and is effective in preventing the re-establishment of the original plants, even where grazing ceases altogether. The reduction of the grass cover to an open condition commonly leads to severe soil erosion.

Some of the most extensive areas of secondary grassland occur in Natal, especially at altitudes from 2,000 to 3,000 ft. (610–915 m.). Much of what Bews has described as "Low Veld" is certainly derived grassland which, if left undisturbed, would return to *Acacia* Grassland. Burning is the chief factor that prevents this regeneration. The presence of the taller grasses, *Andropogon* and allied genera, in quantity in the grassland is very often an indicator of instability and the possibility of progression to savanna or even more advanced types. In all such areas protection from grazing, fire, or other disturbing factor, permits in time a regeneration of the original type.

In addition to the secondary grasslands, which are due to disturbance, there are natural grassland areas which are usually small and local. These are found where the soil or other factor prevents the succession from advancing. Such grasslands occur on the crests of ridges and on recently formed soils along rivers: the last are clearly unstable.

Utilisation.—This type of land has been extensively used for agri-

cultural purposes, and practically every one of the plant communities has been exploited. Both pasturage and cultivation are undertaken. The *Acacia* Grassland provides most of the pasturage and is used for cattle, sheep, and to a lesser extent for horses. The northern parts are unsuited to horse rearing owing to the prevalence of disease, but the conditions are quite favourable in the cooler portions of the south.

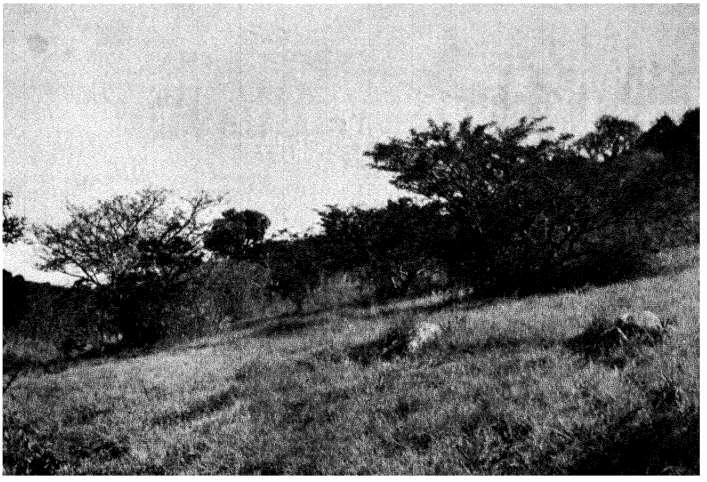
Dairying is the principal industry. In relation to this efforts are being made to increase the feeding value of the pasturage, especially in winter, and to prevent deterioration from overgrazing. For this purpose various crops are grown as additional foodstuffs. Some of these, such as teff (*Eragrostis abyssinica*), lucerne, and others are grown as temporary crops, which are used either directly or after cutting and drying. Others, however, are grown as permanent pasture: of these some success has attended the planting of Kikuyu grass (*Pennisetum clandestinum*). This creeping stemmed grass forms an excellent perennial pasture and, though up to the present planted only on a small scale, has given results that suggest the possibility of very great modifications of the natural vegetation being carried out.

The chief crops grown here are maize and Kaffir corn. Fruit is grown in the coastal areas and in better watered parts inland. Citrus, pineapples and some sub-tropical fruits are the most important. Deciduous fruit is grown on irrigated areas in the drier parts. The only natural product made use of is *Aloe ferox*, which is collected in the Succulent Scrub.

Afforestation.—Tree planting is rather local. The most extensive plantations are those of the Australian wattles (*Acacia mollissima* and *A. decurrens*) which occur at the upper limits of this type in Natal. However, as the greater part of the wattle-growing country is in the Grassland region, details are referred to under that section. Of other planted trees *Eucalyptus* and pines are the most important. A total of 32,530 acres of Government plantations exist at present in this vegetation. There is no doubt that the better watered parts are eminently suited to tree-growing.

LOW VELD

The term Low Veld is applied to the vegetation occupying the less elevated country between the mountains of the escarpment in



PHOT. 8. TEMPERATE SAVANNA at Fort Grey, nr. East London. *Acacia* Grassland with *Acacia karroo* and *A. caffra*. *Themeda triandra* dominant on ground. The rounded tree behind is *Cussonia* sp.

PHOT. 9.—LOW VELD at Setara, Kruger National Park, Transvaal. Deciduous Tree Savanna in winter. *Combretum*, *Acacia* and *Sterculia* spp., etc.

the Transvaal and the Lebombo Mountains on the Portuguese frontier. The type continues northwards to the boundary at the Limpopo River and extends up the valley of that river westwards until decreasing rainfall limits its existence. To the south this type extends through the lower parts of Swaziland, to Zululand, and some of the deeper river valleys in northern Natal.

The Low Veld country is all between 1,000 and 3,000 feet (304–915 m.) in altitude and has a definitely tropical climate, with rather high temperatures and warm frost-free winters. The rainfall is 25–30 inches (63–76 cm.) over most of the region, but is as low as 15 inches (38 cm.) in the upper stretches of the Limpopo valley; on the other hand, amounts as great as 45 inches (114 cm.) are experienced at the foot of the mountains. Throughout the region about 80 per cent. of the rainfall comes in the summer months.

In general terms the region can be divided into three zones, the low ground under 2,000 feet (610 m.) in the east, an upper belt rising over 2,500 feet (760 m.) at the foot of the mountains, and, thirdly, the much drier stretch of the Limpopo valley. These divisions are characterised by distinctive kinds of vegetation, though the boundaries between them are by no means sharply defined. The principal types are given below; each includes a number of units that differ from one another in composition and in other characters.

1. Deciduous Tree Savanna.
2. *Parinarium* Savanna.
3. Dry Deciduous Forest.
4. Riverside Forest.
5. Mopani Bush.

Of these divisions the first is characteristic of the lower lands, the second and third occur on the upper belt, while the last is found in the drier conditions of the Limpopo valley.

Deciduous Tree Savanna.—This is an open woodland community with an undergrowth dominated by tall grass. The tree layer is not quite continuous, but, apart from the dambos, has no large gaps. The intervals between trees are generally much less than the spread of the crowns. The actual cover represents about 75 per cent. The general effect of this vegetation is one more suggestive of woodland than grassland with trees, though in no part is there

much reduction in the intensity of the light reaching the ground. The trees composing it are deciduous except along the rivers. The height of the trees is not very even ; in any one place the general level of the upper stratum is less regular than in any other of the savanna communities of South Africa. The larger trees average about 20–25 feet (6–7 m.), but in places may attain 30–35 feet (9–10 m.). In other parts the height is only 10–15 feet (3–4·5 m.). Trees very large, either in height or in diameter, are rare. Most often there are larger and smaller trees associated together with an irregular external contour, and they frequently have rounded or irregular crowns and not the flat or umbrella shape. In many of the trees the branches are curiously twisted or contorted, a feature possibly correlated with the very dry winter and with the grass fires. The size and form of the leaves vary a good deal. Large and very small leaves are exceptional. Compound leaves are very common, and many of these have very small leaflets. Most of the leaves have a firm though not at all leathery texture, and many are hairy. The surface is dull, not polished.

Beneath the trees is a very discontinuous shrub layer which is quite absent on the poorer soils. Even in the most luxuriant parts the bushes are scattered or in widely separated groups. A few of the shrubs are evergreen. The field layer is dominated by tall grasses which form a stratum 2 4 feet (0·6–1·2 m.) high at the flowering period. Still taller grasses occur in the valleys. While the grasses are definitely dominant, there are a number of undershrubs and herbs mixed with them. The grasses do not form a turf or, in many cases, a complete cover to the soil, though their aerial parts show a continuous stratum. The grasses grow from loose tufts or in clumps.

In the actual composition there is a good deal of variation in accordance with the local conditions of altitude, soil, rainfall, and so forth. The tree layer is most often composed of a number of species associated together without any one definitely dominant. On the deeper soils with adequate rainfall the commonest trees are : *Adina galpini*, *Albizzia* spp., *Combretum* spp., *Commiphora* spp., *Lonchocarpus capassa.*, *Sterculia murex*, *Terminalia sericea*, and many others. *Acacia nigrescens*, a deciduous tree of large size but generally less tall than the other species mentioned, occurs in patches as a local dominant or mixed with other species.

Under drier conditions the cover is more open, and such species as *Peltophorum africanum*, *Securidaca longipedunculata*, *Terminalia sericea*, and *Commiphora* spp. are especially abundant. *Acacia* spp. are less prominent, while the shrubs are few or absent. On dry, rocky outcrops *Faurea saligna* and *F. speciosa*, evergreen bushes or trees belonging to the Proteaceæ, are often abundant along with *Commiphora* and *Combretum*. In such situations *Aloe marlothii* may be very common and the succulent-stemmed tree Euphorbias *E. ingens* and *E. cooperi* abundant.

In damper parts the trees are taller and closer and the grass much taller. The dambos, which are waterlogged in summer, are without trees or have isolated examples of *Ficus* sp. and *Bauhinia*. Where the drainage is better developed *Acacia xanthophlœa*, "The Fever Tree," with pale green or yellow bark, assumes local dominance. By permanent water supplies, along rivers, *Acacia* trees (*A. campylacantha* and *A. dulcis*) and some others occur, along with some evergreens. The fan palm, *Hyphœne ventricosa*, is common locally. The commonest of the evergreen trees are *Trichilia emetica* and *Kigelia pinnata*, a semi-evergreen with sausage-like fruits, which occur along with *Ficus* spp. These fringing communities rarely form more than a very thin strip on the river bank, and even this is frequently not continuous except for a dense zone of smaller bushes.

On the poorer soils, derived from granite, that are found in the northern part of this area, a very distinct community is found. It occurs where the rainfall is rather less, 20–25 inches (50–63 cm.). Many of the soils are very shallow. The vegetation here, while agreeing in general structure with that described above, differs in the almost complete dominance of one species, *Copaifera mopane*. Over large stretches this forms almost pure communities. The trees, which may occasionally reach 30 feet (9 m.) in height, have a somewhat distinct habit owing to persistent horizontal branches over most of the stem. None of the trees attain large dimensions. Other species are associated with the dominant though in much less numbers. The larger trees in this community are well separated from one another, but beneath and between them is a lower layer largely composed of young trees of *Copaifera*. This lower layer may be almost continuous. In addition to the mopani, *Bauhinia thonningii*, a leguminous bush bearing large pods, is abundant in this layer. This two-layered structure gives the community, when

viewed from a distance, an even less regular outline than the Deciduous Tree Savanna. On the poorest or on very shallow soils this layer may be sparse or absent. The ground layer is much less dense and shorter: grasses are dominant, but of a hard type without spreading leaves. *Trichopteryx* sp. is generally the dominant, with *Hyparrhenia* spp. and others abundant on the deeper and damper soils. Except in dambos, the grass cover is not continuous. The rather open character of the ground layer limits the spread of grass fires, and the presence of numbers of young trees and bushes is certainly correlated with this.

In this mopani community the height and density of the tree cover is closely related to the soil characters. In parts the cover is almost complete. On shallow or rocky soils *Copaifera* becomes dwarfed and ceases to be dominant. On koppies rising above the general level it may be absent altogether and a community of small trees is formed, often not exceeding 10 feet (3 m.) in height: *Commiphora*, *Combretum*, *Peltophorum* and *Terminalia* are the most abundant, along with *Faurea* spp. and *Pterocarpus rotundifolius*. On rocks the tree Euphorbias with *Ficus* sp. are the principal plants.

***Parinarium* Savanna.**—This is a characteristic kind of vegetation found on the rather higher ground below the mountains of the escarpment. It occurs at altitudes between 2,500 and 3,000 ft. (760–915 m.) on undulating or level ground with deep soils. On steep slopes or shallow soils it gives way to Dry Deciduous Forest (p. 137).

This type is readily distinguished from any of the others in the Low Veld on account of the presence of a large proportion of evergreen or almost evergreen trees. The tree layer is generally a very open one in which the individuals are widely separated or occasionally in small distinct groups. The trees may be of large size, even up to 40–50 feet (12–15 m.), though most commonly less, and with spreading or rounded crowns. The most abundant species are *Parinarium mobola*, a flat- or narrow-topped evergreen tree, and *Ficus* spp., which may be the only ones, or may be associated with others in small quantity. *Syzygium cordatum* and *Trichilia emetica* occur in valleys, from which they may spread for some distance. The other trees are smaller and most of them deciduous. The commonest are: *Combretum* spp., *Cussonia* spp., *Erythrina* spp., *Terminalia sericea*. *Cassia* sp. and *Bauhinia thonningii* are common

as undertrees or bushes. The undergrowth is a tall, luxuriant grass layer in which *Hyparrhenia* spp. and *Cymbopogon* spp. are predominant. In the valleys the grass may stand 6 feet (2 m.) in height. *Acacia campylacantha*, *A. woodii*, *Albizzia* sp. and others occur in these valleys or damp places with the *Syzygium*. The valley communities show transitions in structure and composition to those of the Riverside Forest.

Dry Deciduous Forest.—The communities grouped here are found close to the mountains and on the slopes of the foothills, where the rainfall is heavier and the climate moister than that of the types described above. A number of communities are included that exhibit some range of structure, but the more complex, which appear to form the climax under the conditions, differ from those described above in having a continuous or almost continuous tree layer. While protection is thus given, the reduction in the amount of light reaching the lower strata is not great.

In the tree layer there is a uniformity in height and in form that is striking and characteristic. The height rarely exceeds 25 feet (7·5 m.). The main stem of the trees is straight and slender and bears a flattened or partially rounded crown. The irregular and contorted branch systems so common in the Deciduous Tree Savanna are not seen here.

The trees are deciduous except in ravines or on very wet slopes where evergreens or semi-evergreens are found. Beneath the main trees are bushes or undertrees which are abundant but rarely form a continuous stratum, and the field layer is composed of tall grasses often associated with large numbers of herbs and undershrubs. Climbers and scramblers are often abundant among the shrubs and undershrubs, but very rarely reach the crowns of the trees.

The community in its typical form is much less dry in character than most of the Low Veld types and can truly be described as a forest. The closed forest is, however, by no means the most common: all stages of transition can be traced from it to quite open savanna types. The closed forest type is formed where there is the greater rainfall, on sheltered slopes, on east-facing slopes of the foothills and in valleys. On the more exposed sites savanna takes its place. The more open communities may be regarded as stages in the development of closed forest, some of which are stable

been attempted, but cannot yet be said to rest on a very substantial basis. Climatic fluctuations at present do not seem to be closely related in South and in tropical Africa.

The extent of climatic change during the human period in this country is still an open question. Alternations of wet and dry periods corresponding to those demonstrated in the tropics or to the alternations of glacial and inter-glacial periods of Europe have been suggested but are not conclusive. One important source of evidence for them is found in the river terraces on the Vaal: there are three of these; the oldest is 200 feet above the present river level, the second 60 feet above, and the third now forming at river level. From fossil evidence the 200-foot terrace dates from the close of the Tertiary Period. The suggestion is made that pluvial periods occurred during the time taken between the formation of successive terraces, which represent dry periods. On the other hand, the phenomena can be explained without recourse to climatic change by uplift of the continent. Elevation of the land has certainly taken place in late Tertiary and post-Tertiary times.

Generally speaking, there does not seem to be evidence for recent or contemporaneous climatic change. Those changes that have occurred are so ancient that the flora has reached a state of equilibrium.

CHANGES IN VEGETATION

Vegetation provides the most exact indicator of the *total* environmental conditions, and any changes in these are reflected in alterations in it. In accounts of the past conditions and climate of the country, vegetation such as forest, which is certainly disappearing, is often quoted as support for the view that the climate is becoming drier. There is not the least doubt that over a large part of the country the vegetation has been altered in the direction of simplification. The communities that are established are such as make less demand for water in the habitat. Some of the changes have already been described and the fact that they are due to interference demonstrated. The chief agents of the changes are overgrazing, burning and the cutting out of woody plants. So widespread has become alteration of this kind that much of the vegetation gives an impression of a less favourable climate than actually exists. Examples are to be seen in the secondary grasslands in the Savanna

above the general level. The most obvious feature distinguishing this community is a very great abundance of *Euphorbia tirucalli*, with leafless green succulent branches, which may be completely dominant under the trees and is always very abundant. More especially in the winter, this gives quite a distinctive aspect to this community as compared with those found further north. In other characters, however, both in structure and in composition, there is much agreement. The common trees are for the most part the same, and there is the same tall grass undergrowth. In these valleys undershrubs and large herbs, often with broad thin leaves, are locally abundant. There is considerable variation in the density of the woody plants. On passing from the valley bottom up the slopes there is very commonly a passage from a dense closed condition to an open savanna. At the higher levels, where the temperatures are distinctly lower, the savanna communities associated with the Dry Deciduous Forest show transitions to communities of the type associated with the Bush Veld.

Riverside Forest.—This is not at all an extensive community here. Forest proper is confined to river gorges cut through the foothills. In the more open country fringing trees alone are present in the river channels. Where fully developed the Riverside Forest is a much more complex community than any of the others in the Low Veld ; the trees are taller, often 50 feet (15 m.), and form a closed canopy. Evergreen trees occur near the rivers themselves, but a short distance from the water deciduous trees are the main builders of the canopy. Climbers are abundant and frequently festoon the trees. Bushes generally form a more or less continuous layer beneath the trees. Many of the bushes have thin leaves that may become dried or wilted-looking in the winter. *Phœnix reclinata* is common in this layer. The ground is covered by ferns and tall herbs, with grasses only dominant in the drier places.

On the valley sides, at greater distances from the stream, this forest passes by gradual transitions into the Dry Deciduous Forest. In the upper parts of the valleys, at higher altitudes in the sheltered ravines, there are strips of forest and some more extensive patches which show features of transition to the Montane Forest of the upper levels. All gradations from one type to the other can be traced on ascending the mountains.

The forest has suffered severely from fires and from felling.

Mopani Bush.—This is the type of Low Veld vegetation that is found in the hot dry conditions of the Limpopo valley, where the rainfall averages 15 inches (38 cm.). The vegetation differs in its much lower stature from that already described; indeed, very commonly, trees proper are almost absent and their place is taken by many-stemmed shrubs or very small trees which have branches from close to the base. Though the trees are small the vegetation is dense. Except on very poor and shallow soils the bush layer is almost continuous, though the degree of shading given is small. The close nature of the bush in these dry conditions is in very striking contrast to the very open type found on the south side of the Zoutpansberg, which here forms the boundary between the Low Veld and the Bush Veld.

By far the most common of the bushes here is *Copaifera mopane*, which is dominant over large stretches. Here it grows as a bush from 3-4 feet up to 10–12 feet. (0·9–1·2 up to 3–3·5 m.). Only in very sheltered situations does it attain tree form or stature, and even there very few individuals show any definite trunk. Usually the plant has branches almost to ground level.

The uniformity of the Mopani Bush is broken by baobabs, *Adansonia digitata*, which occur scattered through the vegetation and tower up above all other plants. These trees stand out as conspicuous objects even from long distances. The baobab trees may attain a great size: 60–80 feet (18–24 m.) is not extreme and they have a wide spread. The trunk reaches an excessive thickness: examples have been measured in which the circumference at breast height was over 100 feet (30 m.). The tree is not confined to this bush, but occurs, though locally, in parts of the Deciduous Tree Savanna. Here it occurs scattered as isolated trees and only occasionally in groups.

Other trees or bushes of smaller size occur along with the dominant *Copaifera*, but always in lesser quantities. Of these *Boscia* and *Commiphora* have the form of small trees, with a trunk and a rounded crown, others are usually of bush form. The undergrowth is sparse and open, with areas of bare soil, tufted grasses, small undershrubs and many annuals. The sparse, open nature of the ground cover, which restricts the passage of fires, is probably responsible for the greater density of the bush cover in these especially dry conditions.

Rocky koppies with shallow soil which occur in this area show a partial or complete absence of *Copaifera;* they are covered by a mixed community of low trees or bushes in which *Acacia litakunensis* (*A. heteracantha*), with both long straight and short curved spines, *Commiphora* spp., *Securidaca*, *Combretum* and others are abundant, with *Euphorbia cooperi*, a succulent-stemmed candelabra tree with jointed branches, in rock cracks. Baobabs are absent. In winter these rocky patches are very distinct owing to the completely deciduous habit of the trees and shrubs, whereas *Copaifera* commonly retains its leaves, though yellow and dry, till shortly before the production of the new ones. In summer a darker shade of green marks the koppies.

At higher altitudes, where the rainfall increases, the Mopani Bush passes gradually into the Dry Deciduous Forest in one of its forms. Baobabs are confined to the lower grounds; they do not occur at heights over 2,300 feet (700 m.).

Along streams in the Mopani Bush larger trees are found, both bigger examples of the trees of the community, and some others confined to such situations, of which *Acacia woodii* and *Combretum erythrophyllum* are the commonest. *Syzygium* is confined to permanent streams with sheltered valleys; *Hyphane* occurs locally.

The Mopani Bush is closely related to the other Low Veld communities and represents a development under much drier conditions, conditions that represent the lower limit of moisture possible for this type.

Modifications.—Parts of the Low Veld vegetation, and especially the parts at higher altitudes, have been a great deal altered from their primitive state. The greater modification at the upper levels is largely correlated with the climate. The low grounds are tropical and unhealthy and have a small population.

Throughout the region fire, tree felling and grazing have rendered some of the vegetation more open than it was at one time. This Low Veld has, however, been less extensively modified than most other types in the country. Stretches of treeless grassland are not uncommon on the hill slopes or near settlements, and are certainly of derived origin. In the low grounds the almost treeless condition of many of the river banks is certainly attributable to the felling of the larger trees. The subsequent grass fires prevent or hinder regeneration. In this connection the state of the palm, *Hyphæne*

ventricosa, is deserving of mention. It is rare, except in very remote parts, to find tall, full-grown plants. The palm occurs as a stemless individual. The natives cut the tree for the sake of the fruits and inflorescence.

A parallel though rather more extreme case is that of the baobab, *Adansonia digitata*. The bark of young trees is stripped for use as cordage or other purposes. This has been carried on to such an extent that juvenile trees are very rarely seen. While adults are not at all uncommon there is no trace of regeneration. In the course of two days spent traversing the vegetation of the Limpopo valley only one young tree was seen, and this had a circumference of 3 feet (1 m.). It is probable that the rather erratic distribution of baobab, especially in the eastern parts of the country, is largely the result of this prevention of its regeneration.

The Deciduous Tree Savanna and the Mopani Bush have been less affected by interference than the other types. The *Parinarium* Savanna, which occupies a zone of fertile soil with a large native population, has been much modified, so much so indeed that untouched portions are infrequent and small. Stretches have been cleared completely or now retain only a few scattered trees, often confined to the steeper slopes or to ravines. Even where clearance has been less complete, grazing, trampling by cattle, and fire have changed the undergrowth very much. Instead of the tall grass, there is a low cover of creeping or tufted grasses which is sometimes incomplete. Undershrubs and bushes, such as *Royena* sp., may become very abundant in these changed areas.

The Dry Deciduous Forest has also been modified to a considerable extent locally. In areas where this vegetation would be expected there is now grassland with or without low bushes. Small patches of the original community occur here and there, or in some cases isolated trees of *Pterocarpus*, *Terminalia* or *Syzygium* alone represent the former condition. Fire has been the chief agent of destruction, so much so that in some places untouched vegetation is confined to protected spots below cliffs or among rocks. Various shrub thickets and open tree communities represent the result of less drastic interference.

Development and Succession.—No detailed knowledge is available on the phases of succession in this kind of vegetation. What can be said is based on general observation and comparison.

The Dry Deciduous Forest probably presents a more extensive series of possible stages in development than any of the others. These are traceable principally in the re-growth after destruction. The actual sequence varies in many features in accordance with the local conditions, and only the most general characters can be dealt with. After complete destruction, tall, rather rank grass becomes dominant. There is usually a large mixture of herbs and undershrubs in this phase. In the absence of immediately succeeding fires, woody plants make their appearance in this grassland, at first scattered, but later becoming closer. *Acacia* spp. are usually the first to become prominent, often associated with *Peltophorum*, and locally with *Parinarium; Terminalia*, *Combretum* and *Bauhinia* appear later. *Pterocarpus*, *Erythrina*, *Cussonia* and others are rare in the earlier phases except where they are undoubtedly survivors. It is worthy of note that communities largely composed of trees or bushes of *Acacia*, with some *Peltophorum* and *Combretum*, occupy positions at the foot of some of the hills where apparently decreased rainfall has prevented the succession from advancing beyond this relatively early phase. In the wetter parts *Syzygium* regenerates rapidly and, with *Albizzia*, may become dominant.

In the regeneration of the Riverside Forest there are examples where the succession passes through stages that are almost identical with the Dry Deciduous Forest, and others where such stages are replaced by the semi-evergreen *Albizzia-Syzygium* community. Such are, however, confined to places with large moisture supplies, and do not mean that one or other of these communities is the real climax over the whole area. The partially closed *Pterocarpus-Terminalia* community is undoubtedly the climax generally. In this community the stable undisturbed climax is characterised by a number of shade-loving plants in the undergrowth which are absent in re-established examples.

In the *Copaifera* communities the dominant tree is the one that appears first on unoccupied or cleared land. The others associated with it make their appearance later. For example, in the bed of the Limpopo changes in the channel have left stretches of sand, mud or stones, and these are rapidly colonised by *Copaifera*, which at first forms a practically pure community.

Very little indeed is known of the development of the other types of Low Veld vegetation.

Utilisation.—The whole area is tropical and though well supplied with streams and rivers, is liable to malaria. The lower ground is rather unhealthy and has a very small European population and not at all a big native one. Though many of the soils are deep and probably fertile the climate is such that any use of the soil is local only. A large tract of this lower country along the Portuguese frontier, extending from the Crocodile River in the south to the Limpopo in the north, has been set aside as a national park and game reserve, the Kruger National Park.

The upper zones are healthier and have a much larger population. This part has been much used by natives and to some extent by Europeans. The European population was at first attracted by mining, which is still carried on in various places on a small scale. Agricultural occupations are becoming increasingly important in the Low Veld. Owing to disease cattle and horses are not kept, though there are a few native herds. The main productions are fruit, cotton, maize and tobacco. Of the fruit citrus is much the most important, and the Low Veld is the biggest centre of its cultivation. Various sub-tropical fruits are grown in smaller quantities.

Afforestation.—Planting has been carried out on the higher parts and especially in the zone of the Dry Deciduous Forest. *Eucalyptus saligna* is the species grown most extensively. Other species of *Eucalyptus*, *Pinus patula* and *P. tæda*, are also grown: the two last are much less successful here than in the cooler and moister conditions of the Montane Forest. *Acacia mollissima* and *A. decurrens* are planted but are not very successful. *Cassia siamea* has been shown to be a very fast-growing tree under these conditions and very suitable for wind breaks. It provides a useful supply of firewood.

BUSH VELD

The vegetation included under the heading Bush Veld occupies the northern portion of the plateau in the Transvaal. The region is bounded on the south by the Magaliesberg and the high ground running eastwards to the escarpment near Lydenburg. The escarpment mountains and the Limpopo valley mark its limits on the east and north. The western boundary is less definite; it follows approximately the line of 18 inches (45 cm.) rainfall. The country varies in altitude between 2,000 and 4,500 feet (610–1,370 m.): it

is far from uniform topographically, the general level of the table-land being broken by mountain ranges and by the channels of the tributaries of the Limpopo, some of which have carved out deep ravines.

The climate in this region is distinctly less tropical than that of the Low Veld. The altitude and dryness mitigate the effects of the latitude. The rainfall is 20–30 inches (50–70 cm.) and is concentrated in the summer months; the winters are dry, with cold nights and some night frosts. The temperature is lower than in the Low Veld, especially in the winter, and has a greater range. The accompanying table will illustrate the differences between the two types:—

TABLE 28.—*Temperatures of Bush Veld and Low Veld*

	Bush Veld.		Low Veld.		Difference.	
	°F.	°C.	°F.	°C.	°F.	°C.
Mean Temperature.						
Annual	64·6	18·1	71·2	21·7	— 6·6	— 3·6
April–Sept.	58·5	14·7	67·7	19·8	— 9·2	— 5·1
Oct.–March	71·1	21·7	76·9	24·9	— 5·8	— 3·2
Mean Maximum Temperature.						
Annual	78·4	25·7	88 9	31·6	— 10·5	— 5·9
April–Sept.	73·9	23·3	81·8	27·6	— 7·9	— 4·3
Oct.–March	82·9	28·2	90·0	32·2	— 7·1	— 4·0
Mean Minimum Temperature.						
Annual	51·5	10·8	56·3	13·5	— 4·8	— 2·7
April–Sept.	42·9	6·1	55·8	13·2	— 12·9	— 6·7
Oct.–March	58·9	14·9	65·5	18·6	— 6·6	— 3·7
Mean Range of Temperature.						
Annual	47·6	26·4	41·0	22·8	6 6	3·6
April–Sept.	43·7	24·3	36·6	20·3	7·1	4·0
Oct.–March	29·0	16·1	27·6	15·3	1·4	0·8

In correlation with the less tropical conditions, the vegetation is of a simpler structure; the tree stratum is much more open; the trees are smaller, more uniform in size, and deciduous. The grass layer is shorter; the dominant grasses form a more continuous stratum, made up of loosely tufted plants with basal leaves or short basal branches. The tall-stemmed grasses, so common in the Low Veld, are not conspicuous here.

The tree layer is rarely sufficiently complete to have a real

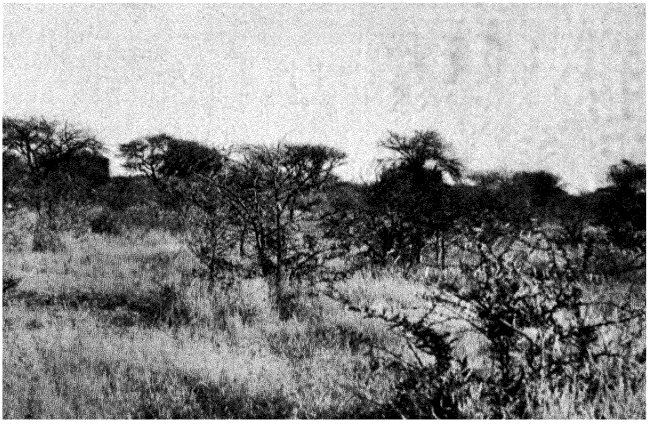
dominance over the undergrowth. Much of the Bush Veld vegetation would be better described as a grassland with trees than as a woodland. There is only rarely any complete development of a second stratum of woody plants.

The Bush Veld represents the reaction of the Tree Savanna type to cooler and more temperate conditions. While there are gradual transitions to the Low Veld type, in its typical development this is quite distinct.

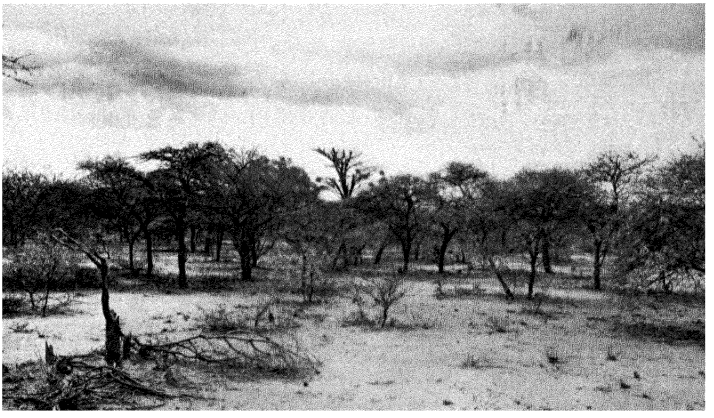
The somewhat diversified topography in this region is associated with minor changes in the conditions, often occurring within quite short distances. Each has its characteristic vegetation, but much more study is needed before a satisfactory arrangement of the component communities can be arrived at. At present a grouping based on the major structural features is adopted. Each of the subdivisions certainly contains a number of units differing from one another in detail and in composition. The subdivisions are :—

1. Small Tree Savanna.
2. Bush Clump Savanna.
3. Scattered Bush Savanna.

Small Tree Savanna.—This is much the most extensive and, though by no means constant in details either of structure or of composition, is the characteristic vegetation over large areas. It is a community of small trees scattered at varying distances in a grass undergrowth. The tree cover varies from a very open one to a nearly continuous stratum. Most commonly the distance between the trees is greater than their crown-spread. Bushes occur scattered through the community but their numbers and arrangement are too irregular to constitute a second stratum of woody plants. The differences in the closeness and size of the trees often runs parallel with the prevailing climatic characters, but is not always correlated with them : adjacent areas on different kinds of soil may show very distinct differences in tree size and abundance. Excellent samples of this can be seen at the western extremity of the region where the rainfall is 23 inches (58 cm.) or less and the average humidity very low. Here on deeper soils there is an open savanna of *Acacia*, *Peltophorum* and other trees standing about 15 feet (4·5 m.) high but widely separated ; on rocky soils adjoining is a bush community,



PHOT. 10. -BUSH VELD near Nylstroom, Transvaal. Small Tree Savanna in winter. *Acacia* spp., *A. karroo* in foreground, with rather tall grass.



PHOT. 11.—BUSH VELD at Eland's River near Pretoria. Small Tree Savanna on granitic sand. *Acacia litakunensis* and *A. arabica* var. *kraussiana*: the ground is bare as the result of drought and grazing. (Photo: I. B. Pole Evans.)

[*Facing p.* 146.

mostly composed of *Combretum zeyheri*, a hairy bush or small tree, with the bushes only 3–6 feet (1–2 m.) high, but forming an almost continuous layer.

In the more luxuriant parts a rather regular tree layer is formed, giving so distinct a structure that it may be regarded as constituting a sub-type—"Park-type Savanna." This is built up of trees usually 10–15 feet (3–4·5 m.) high, though occasionally reaching 20–25 feet (6–7·5 m.). The trees are flat-topped or umbrella-shaped and separated by distances varying from a few feet to several yards. Very often the trees are extremely regular both in spacing and in height; it is this regularity in arrangement that gives this sub-type the characteristic park-like appearance. The height, spacing and spread of the trees vary with local conditions of climate, soil and other factors. The tree layer may be dominated by a single species or by several associated together; in the latter case there is more variation in actual form. This "Park-type" occurs on deep soils in the parts with better rainfall.

In other parts there is much less regularity in the trees. Acacias are the most abundant trees throughout and are sometimes dominant. The tree distribution is closely correlated with soil characters; *Acacia* and *Peltophorum* dominate on loams; *Burkea* and *Terminalia* on sands; *Combretum* on red sandy loams; *Acacia* on black soils. On soils that are liable to be very wet in summer and which are usually alkaline *Spirostachys africanus*, a small deciduous flat-topped tree with slender branches, is dominant. Tree Euphorbias occur on rocky soils. A number of other trees occur, and some of these may attain dominance.

The grass layer is typically continuous and largely formed of loosely tufted species; it rises to about 3 feet (1 m.) at the flowering time. *Themeda triandra* is the general dominant, with *Setaria*, *Panicum*, *Ischaemum* and others which are more local. *Tristachya pedicellata* is a common dominant in dambos. In the drier parts an almost turf-like layer of low tufted grasses is found.

Within the Small Tree Savanna there are many distinctive subdivisions, of which a very characteristic one is found on rocky ridges where the soil is very shallow. In such situations *Protea abyssinica* and *P. roupelliæ*, evergreen shrubs with pale rather heavy leaves, and *Faurea saligna* are the most abundant, often the only trees. They form an open community with a sparse low grass

undergrowth dominated by *Aristida*. This *Protea-Faurea* community is distinctive both in habitat and in structure; the trees have persistent leaves and form rounded or elliptical crowns very dissimilar from the ordinary umbrella form. The Proteaceous trees may constitute the whole of the upper layer or be associated with others such as *Combretum*, *Burkea*, *Terminalia*, and especially *Commiphora*. Acacias only occur where there are greater accumulations of soil. On the crests of ridges *Protea* is often the only woody plant. *Aloe marlothii* is often very abundant on steep, rocky slopes where sheltered or not too dry. It may occur to the exclusion of bushes or mixed with them.

Bush Clump Savanna.—In its typical development this is a distinct type and the most complex of the Bush Veld. The trees occur in groups, often quite dense, with almost treeless stretches between. The clumps vary in size and in proximity; they range from patches a few yards across to thickets of more than 100 yards. The actual construction varies from groups of contiguous trees to dense thickets with two definite layers. The clumps occur on or around ant-heaps, and this kind of vegetation does not occur on those soils where ant-heaps are not formed. In the denser clumps bushes form an almost continuous layer below the trees, and among them are several evergreen species. A few evergreen trees occur in damper places. The trees in the clumps are taller than those in the open; most of the trees of the Small Tree Savanna are found here along with several others. Scramblers and a few climbers, such as *Clematis*, may be prominent but rarely extend beyond the shrubs: "strangling figs," which commence as climbers and continue as independent plants after the death of their support, are found locally.

All stages of transition can be found between the dense clumps and the open savanna kinds of vegetation.

Scattered Bush Savanna.—In most of its characters this forms the vegetation that is transitional between the typical savannas of the Bush Veld and the Grasslands. It is found especially at the southern margin of the Bush Veld region, but also occurs in the open and dry parts of the plateau where low temperatures are experienced in winter. Large stretches of country are occupied by this kind of vegetation on the gently undulating plains west and north of Pietersburg.

The Scattered Bush Savanna merges imperceptibly into the Small Tree Savanna, but is a distinct type in structure, composition and in habitat requirements. It is a grassland with scattered woody plants, very often not more than 4–6 feet (1–2 m.) high. In spite of their small size a large percentage of these have single stems with rather flattened crowns. Bushes, however, do occur mixed with these diminutive trees. The small trees and bushes may be many yards apart; at times they do not cover more than 5 per cent. of the total area, but they may be much closer. Their numbers are closely correlated with climatic and soil characters. Most of the woody plants are deciduous, but some have persistent leaves which are often pale green and not shining or leathery.

The grass layer is continuous, or nearly so, but is not very dense. The grasses grow in loose tufts, persistent in winter, and reach a height of 2–3 feet (0·6–1 m.) at the flowering period. *Themeda triandra* is the most general dominant, but is very often associated with many other species, some of which may be local dominants. Rather numerous herbs and undershrubs occur along with the grasses; these may make up as much as 30–40 per cent. of the ground cover. Succulents are not uncommon on shallow or rocky soils; in such places the bushes are closer together.

The bushes and small trees show variations in their distribution in different parts of the region. In the southern parts *Acacia caffra* and *Protea caffra* are the most abundant. In the northern parts of the region *Acacia rehmanniana* is abundant and may be the only tree or be associated with *Combretum* spp., *Euclea lanceolata*, an evergreen shrub or small tree with black bark, and *Peltophorum africanum*, an acacia-like semi-evergreen tree. Proteas and small Acacias are generally the characteristic plants in the marginal zones.

The boundary between the Scattered Bush and the Grassland is a gradual one except where the configuration of the ground makes a sharp limit to the prevalence of severe frosts. On some of the eastern mountain slopes the Scattered Bush occupies steep slopes up to 4,000 feet (1,220 m.). The higher levels and more gentle slopes are grass-covered. Within the savanna area hills with gradual slopes are grass-covered, whereas steep-sided ones bear bushes to higher altitudes. Steep-sided elevations also carry bush even beyond the general boundary of the savanna type. Examples can be seen in

the south as far as the main Witwatersrand watershed. Bush becomes confined to steep ridges, valleys and gentle slopes are covered by grass.

That the very open nature and the dwarfed character of this woody vegetation is the result of frost prevalence is clearly shown by the increase in height and in proximity wherever protection is provided. On the steeper slopes the trees are larger and closer, even though the soil is poorer in quality. In very sheltered spots trees, such as *Celtis kraussiana* and others not general in the community, may build small scraps of woodland which have an almost closed canopy.

Along streams and rivers larger trees occur and there are a number of species absent from drier situations. These larger trees do not form more than a narrow fringe along the streamsides.

Modifications.—The most obvious changes wrought in this vegetation are the result of clearing the land of trees. Large stretches of grassland country occur which were certainly at one time covered by savanna, but from which all woody plants have been removed. In other places less complete clearance has left grassland with a few scattered trees. Many of the more open communities, other than the marginal ones, are the result of the cutting of trees. Regeneration is checked by the frequently recurring grass fires. Where fires are prevented or are less frequent, bushes, many of which are spine-bearing, occupy the land after the removal of the original trees. *Gymnosporia*, and more especially low-growing or creeping species of *Acacia*, are very abundant. These spinous bush communities may become rather dense and are definitely detrimental, as the growth of grass is prevented and the spinous shrubs are harmful to animals. Such bush communities are most prevalent on land that has been overgrazed and abandoned. They often mark the sites of old native settlements.

Changes occurring in the woody plants are the most apparent, but others quite as important, if not more so, occur in the ground layer as the result of clearing, burning or grazing. The changes here are very much like those brought about by the same causes in true grassland. They are dealt with at greater length in the section on Grassland (pp. 170–1), and no details will be given here. The broader leaved and softer grasses, *Panicum*, *Themeda* and others, are reduced and their place taken by harder, often tufted, kinds. In the

extreme cases the only grasses present are low, creeping species. The presence in quantity of *Cynodon* spp. is quite a certain indicator of destruction in the field layer. In some cases grazing has been carried to such an extent that the field layer has ceased to be continuous and an open cover with patches of bare soil results.

Development and Succession.—In their natural and undisturbed state the various subdivisions of the Bush Veld vegetation represent a series that exhibits the reactions to conditions progressively more favourable to the development of savanna vegetation. The Scattered Bush Savanna is the kind developed where conditions are near the limit possible for Tree Savanna at all. With more favourable conditions, especially as regards frost and rainfall, the Small Tree Savanna is formed. The " Park-type " and Bush Clump Savannas represent the ultimate development in the most favoured parts of the area. The Bush Clump is structurally the most complex of the communities of the Bush Veld. Even with complete prevention of fires and elimination of all grazing, both of which tend to maintain an open structure, it is exceedingly doubtful whether the clumps could ever extend to such an extent as to become continuous. The low rainfall, and especially the prolonged dry winter season, are adverse to such a development. The probable ultimate phase would be bush clumps with trees scattered between. The Bush Clump is a climax on certain types of soil, but is restricted to those in which ant-heaps are formed. On other soils a savanna more like the " Park-type " would be the climax. The " Park-type " itself, with its absence of woody undergrowth, certainly owes some of its characters to the grass fires. It can pass to an open clump or closed tree-group vegetation. Under existing conditions it certainly appears to be stable in many instances.

In the development of these more advanced kinds of community, stages are passed through that have the characteristics of the less complex ones. Both the Scattered Bush and the Small Tree Savannas are climax communities under the less favourable conditions. They are developmental stages that are stable where further development cannot take place.

The very open character of the tree cover of so many of the Bush Veld communities is certainly attributable to frequent fires and to grazing. When fires are prevented, and grazing is regulated, there is generally an immediate increase in the numbers of young trees.

In time a much closer tree layer would be developed with a tendency to clumps where the soil conditions are suitable. As soon as closure of the cover occurs a number of shade-demanding plants can obtain a foothold.

In the developmental phases as observed *Acacia* is generally the first tree to colonise open or cleared areas of grassland. Many patches of abandoned, cleared or cultivated land now bear communities of small Acacias, some of which are low-growing bushes, not trees. Later the dominance of *Acacia* gives way before the increase in other species. On sands *Burkea africana*, not *Acacia*, is the pioneer tree species. Later this tree tends to decrease in quantity when the dominant *Terminalia sericea* becomes established. In the later phases *Burkea* does not seem able to reproduce at all when fires are checked.

The *Protea-Faurea* community is an early phase that is stable under conditions where a lack of soil prevents further development. *Protea* communities are also common at the extreme margins of the Bush Veld. The succession phases in the grass layer run parallel to those in the upper stratum.

Utilisation.—Most of the Bush Veld region has been rather recently settled and occupied by Europeans, and the full possibilities of the land have not been ascertained either for agricultural or other purposes. Though very nearly within the tropics, the climate is modified by the altitude and dryness, and most of the region appears healthy and suitable for European settlement. Such diseases as malaria are general, except in the highest parts, but with due precautions are not severe.

The principal activity in the Bush Veld is cattle ranching. Crops are grown in valleys and where water is available, but are very often on quite a small scale. The chief crops are maize, Kaffir corn, tobacco and fruit, especially citrus. Deciduous fruit is grown on a small scale.

The grass-covered land with its open tree growth is excellent for ranching purposes. Horses cannot be reared at present owing to the prevalence of horse-sickness. Even mules must be inoculated. Donkeys, on the other hand, appear to be immune. Sheep and goats are liable to a tick-carried disease which prevents the successful keeping of large flocks. Dipping and other precautions are certainly improving the conditions and the numbers maintained

increase from year to year, but even now are small as compared with the more important sheep-rearing regions.

Cattle rearing, however, flourishes and is the chief activity of the inhabitants, much of the farmland being entirely devoted to this purpose. To be really successful here it is essential to obtain some understanding of the development and reactions of the vegetation, otherwise veld deterioration begins.

The denser forms of bush have a reduced grazing value, but very open types are without the most valuable fodder grasses which demand a certain degree of shelter. The practice of grass burning is closely related to the grazing conditions for cattle. Land very frequently burned has few trees and bushes and poor, hard grass. The best state is probably the "Park-type" or other Tree Savanna, with sufficient cover to give conditions suitable to the more valuable grasses and not so much shade that the growth of the ground plants is reduced. The absence of bushes, too, allows free movement to the cattle. The object in view must be to maintain this condition. Occasional controlled fires will effectively stop any tendency to the development of dense clumps. The maintenance of a suitable tree cover is, however, not sufficient. The intensity of grazing must not exceed what can be carried by the grass layer without its undergoing alterations that are almost always deteriorations. The grass-grazing balance is most easily kept by the paddocking system, by which each part gets a period of rest.

The dry climate and the long dormant period of the grasses prevent the possibility of any concentration of cattle without serious detriment to the vegetation. While the general conditions of climate, fodder and so forth are suitable for dairy production, this can only be carried on on a scale more than sufficient to meet local needs when additional fodder is provided for the winter period. Various crops are being grown for this purpose. Though at present such plantings are on a small scale, the results are such that probably some increase in winter food will become a normal practice. It is possible that the use of the natural grasses as hay might be helpful.

The Bush Veld vegetation has not produced any plants of economic value. Some of the trees have wood suitable for cabinet making or other purposes where large size is not essential. The irregular shapes and scattered distribution are obstacles to any kind of usage.

Afforestation.—The low rainfall, high evaporation, and long dry

season make the region of little value for tree planting. The only parts used for plantations are at the higher levels where the rainfall is greater. Some of the drought-resistant species of *Eucalyptus* have been planted locally with some success, but on a small scale. Individual trees of various kinds are planted round farms and some of them make good growth.

BUSH SAVANNA

This type occupies an area of rather low rainfall and strongly continental climate in the Cape Province north of the Orange River. It covers most of what was at one time known as British Bechuanaland. The actual boundaries of the type are not very sharp, rather gradual transitions occurring between it and the surrounding vegetations. The eastern boundary is marked approximately by the line of 18 inches (45 cm.) rainfall; the southern one by the valleys of the Orange River and its tributaries the Modder and Riet Rivers. In the west the limit runs along the western border of the higher ground of the range of the Langeberg, which trends north-north-eastwards from the Orange River between Prieska and Upington. This range is somewhat indefinite, with many foothills extending westwards into regions of very low rainfall. Beyond these general boundaries the vegetation extends along river valleys, especially into the arid parts.

The region as circumscribed is uniform in its climatic characters but not in topography or in geological structure. Most of the area is over 4,000 feet (1,220 m.). There are ranges of hills, rising 1,000 feet (304 m.) or more above the general level, which run approximately north and south. These ranges form the watershed between the Molopo and Vaal Rivers. Between these hills and the valley of the Vaal is a level limestone plateau, the Kaap (or 'Ngaap) Plateau. The northernmost parts of the region are an undulating plain covered by Kalahari sand.

With the exception of the few larger rivers the whole area is rather waterless. The streams originating in the watershed are dry for much of the year. Some permanent springs occur along fault lines, but surface water is generally lacking. Over much of the area, however, water can be obtained by boring. Underground water channels occur in the dolomitic limestone and occasionally come to the surface: an example of this is the Kuruman River, which produces a

large perennial supply at its source but of which the permanent bed in the lower portions is dry except after heavy rains.

Pan-like depressions are not uncommon in the limestone areas; these vary from a diameter of a few yards to a mile or more. They are often nearly circular; in depth they vary from 3–15 feet (1–4·5 m.) and may hold water in the rainy season.

The vegetation is of a semi-arid type: all the communities are open though the degree of soil exposure varies a good deal. As compared with the other savanna types this Bush Savanna differs in the frequent dominance of bushes with persistent leaves. The upper stratum is generally composed of bushes or small trees, ranging in height from 2-3 feet (60–90 cm.) to 10 feet (3 m.) or more. The bushes are generally quite separate, only rarely forming any sort of group. The ground vegetation is open and often largely made up of annuals.

The type includes a number of communities with very different compositions which are closely correlated with differences in the soil. The chief divisions are:—

1. *Tarchonanthus* Bush.
2. Low Bush.
3. *Olea* Community.
4. *Acacia giraffæ* Savanna.
5. *Acacia* Bush.

***Tarchonanthus* Bush.**—This is the most extensive of the various divisions. It is a community of low bushes scattered in an open undergrowth. The characteristic bush is the evergreen *Tarchonanthus camphoratus*, which occurs isolated or in loose clumps which vary in height from 2–3 feet (0·5–1 m.) up to 6 feet (2 m.). The pale, hairy twigs and young foliage give the community a characteristic appearance. *Tarchonanthus* may be the only bush or occur associated with others in varying proportion. Of these *Acacia stolonifera*, a low deciduous bush with spines, is nearly always present. Other very common bushes are *Acacia detinens*, *Rhus ciliata*, *Royena pallens* and *Zizyphus mucronatus*. The ground layer is open and consists mainly of grasses, a very large number of which are annual and form a thin layer in summer. On the shallower soils *Chrysocoma* and *Pentzia* form an open layer. Geophytes are fairly common but succulents are scarce.

The nature of the field layer changes with the character of the

soil: on deeper, and especially on sandy, soils perennial grasses are much more abundant. On such soils, where the rainfall is larger, the bushes are widely scattered and quite extensive open grassland patches occur. Grass without bushes also occurs in dambo-like valleys. In the northern parts there are large stretches where the bushes are of very small size and widely separated from one another. A casual view might easily suggest a grassland community.

This *Tarchonanthus* Bush occurs on all except the very shallow types of soil.

Low Bush.—This includes a number of communities that differ in composition but agree in structure and in habitat. All are developed on very shallow silicious soils.

In the northern parts the principal bush of this savanna is *Royena pallens*, which grows as a rounded evergreen shrub, 3–5 feet (1–1·5 m.) in height. The bushes are usually well separated from one another and form a striking contrast to the irregular shaped and pale *Tarchonanthus* on deeper soils. Various species occur along with the dominant but in smaller numbers. The ground flora is very sparse and open; undershrubs such as *Pentzia* are occasional, but the chief constituents are annual grasses. Some succulents and semi-succulents occur under the bushes but not in the open. In the southern part, where the rainfall is less, a more mixed community is found which may have closer bushes, though these are always of small size. The spinous and almost leafless *Lebeckia macrantha* is abundant along with Aloes and various shrubs. A more luxuriant bush community occurs on the Langeberg, where the higher rainfall permits a growth of more deciduous bushes and a greater proportion of perennial grasses in the underlayer.

The Low Bush type of community occupies the steeper shallow soils other than limestones throughout the region.

***Olea* Community.**—This is found on limestone soils, both those formed from the dolomite itself and from redeposited lime. The soils are pale and contrast with the red or red-brown soils of other parts of the region. The characteristic plant here is *Olea verrucosa*, which forms a small tree 4–12 feet (*c.*1–4 m.) in height, with dark evergreen foliage. The trees have close rounded crowns; they are scattered at varying intervals but always separate. In exposed places they are many yards apart. These *Olea* trees are associated with low bushes of *Tarchonanthus*, *Acacia stolonifera* and others.

Larger bushes and trees occur immediately under or growing with the dominants. In the north-east a more varied flora in this community marks a transition to Bush Veld communities.

The undergrowth is very sparse ; *Pentzia*, though never abundant, is the commonest perennial. Tufted grasses are quite absent, though grasses with creeping stems are locally abundant. The presence of tufted perennial grasses is a sure sign of increasing soil depth. With varying amounts of soil over the limestone all transitions can be traced between the *Olea* community and the *Tarchonanthus* Bush.

On the limestone areas pans occur which are quite treeless and grass covered. The grass forms an almost or quite closed cover that stands 2 feet (0·6 m.) high at the flowering time. The soil in these pans is deeper and alkaline, and *Salsola* and other species of salty soils are found.

***Acacia giraffæ* Savanna.**—This is the most luxuriant of the communities of this type and is found on red sands of at least 2–3 feet (0·6–1 m.) depth. Such areas are confined to the northern parts of the region. Here the woody plants occur as trees, often small in size, with flattened or rounded crowns which produce a park-like landscape. Species of *Acacia* are the most abundant : *A. giraffæ*, *A. robusta*, and less commonly *A. karroo*. The first is much the most characteristic ; it has very small spines and may occasionally reach a height of 20 feet (6 m.), but is usually much smaller. The trees are spaced except in sheltered valleys ; below and between them are bushes which are nowhere very abundant. The field layer is open and grassy, but most of the grasses are annual. A few undershrubs occur with the grasses. The size and abundance of the trees in this community vary according to local conditions. Where, under sheltered conditions, the trees are associated in groups, some shade-loving plants such as *Pteridium aquilinum* occur. In the sand-covered valleys that run into the hills the Acacias become quite small, 4–5 feet (120–150 cm.). Such communities of low Acacias are sharply contrasted with the *Tarchonanthus* Bush which covers the adjacent slopes.

***Acacia* Bush.**—This covers extensive areas on moderately deep soils other than sands or limestones. It is especially developed in the eastern and north-eastern parts on soils derived from Karroo rocks or Ventersdorp lavas. This community has some characters

in common with that described above : it is an open savanna of bushes or small trees, principally Acacias, with an open grassy undergrowth. The trees may attain 12–15 feet (3·5–4·5 m.) in height, but are very often much less. The larger ones are flat-topped. The degree of spacing among the trees is very varied. Most of the woody plants here are spinous, and the names " Thornveld " or " Griqualand West Thornveld " have been applied to the vegetation. The commonest trees are *Acacia litakunensis*, *A. detinens* and *A. robusta* in the northern parts. Associated with the Acacias are others in lesser quantity and often evergreen. Plants of bush habit are more common than those of tree form. The undergrowth is open, sometimes very open, with grasses predominating. Perennial grasses, which are tufted, may be abundant, though in the driest parts *Pentzia* is more common. Annuals are very numerous. The density of the field layer bears a close relation to the amount and time of the rainfall.

On undulating sandy plains in the northernmost part of the country there is a community allied to this *Acacia* Bush. The woody plants are small trees, mostly Acacias, very thinly scattered. Not infrequently they are confined to depressions and the more exposed parts appear quite treeless. The field layer is an open one with tufted grasses general. *Acacia* Bush extends along river valleys, far beyond the ordinary limits of the Bush Savanna area, both eastwards into the Grassland and westwards into the arid regions.

Development and Succession.—No detailed work of any kind has been done on this type, which is one of the least known in the country.

The divisions that make up the vegetation are closely related to one another in spite of the apparent contrasts in structure that they show. This relationship is exhibited in the intimate geographical association : *Tarchonanthus* Bush occurs here and there throughout the region, and shallow soils on koppies or steep slopes are always covered by low bush. There is a striking correlation with soil characters in the distribution : the *Olea* and *Acacia giraffæ* types are especially sharply differentiated in this way. On the southern part of the Kalahari plain those parts where lime is present at or near the surface are covered by *Olea*, and even from long distances they can be picked out from the *Acacia* vegetation on the surrounding sand.

The communities in which the upper stratum is of tree form are apparently the most advanced phases of development. The *Acacia giraffæ* Savanna, the *Olea* community, and the more luxuriant parts of the *Acacia* Bush can be regarded as climax communities separated from one another by the characters of the soil.

The lower bush communities are developmental stages which are very often stabilised owing to unfavourable conditions of soil or local climate. The Low Bush is certainly such a phase : it gives place to the *Tarchonanthus* Bush or some other type wherever soil can accumulate. Cutting out of trees and grazing have caused the establishment of *Tarchonanthus* Bush on various soils where one of the tree communities would be expected. The low bushes provide sufficient shelter for the growth and regeneration of the trees if left undisturbed.

Development does not necessarily pass through the stage of *Tarchonanthus ;* small Acacias, especially bush forms, may be the first woody plants to obtain a foothold. A good example of this can be seen on the sides of the large hole of the now disused Kimberley Mine, where a strong growth of Acacias is developing.

Modifications.—Though a somewhat arid and waterless region, settlement occurred in parts a long time ago and alterations in the vegetation have resulted. Tree cutting and a resulting simplification are rather general in the occupied areas. Tree cutting for firewood and for mine props has been most pronounced in the eastern and southern portions of the area. Under the original conditions there was a broad zone of transition between the Bush Savanna and Grassland types. Much of this zone is at present grassland of an open character. The existence in it of isolated trees or bushes, stumps or occasional bush-covered areas, demonstrates the changed character. In the drier parts to the south the removal of timber has reduced the vegetation to a condition in which communities of low undershrubs or open grasslands occur with only isolated trees or bushes. The former condition may be gauged from some of the older accounts. For example, Burchell, in the description of his travels, emphasises the difficulties experienced in getting his waggon through the dense thorn bush of the Orange River valley near Prieska, where now there is little more than a fringe.

Signs of regeneration are found in the denuded parts, but this is retarded or even stopped by grazing, which is very general through-

out the region. Grazing itself has brought about changes which are often additional to those due to wood cutting. The sparse nature of the ground layer is not able to support any intensive grazing. Where animals are present in quantity the grasses are eliminated and their place is taken by low woody undershrubs. Grazing tends to reduce the bush layer by trampling or cropping. The general results of interference in this vegetation are to make the communities more open and more arid in character.

Utilisation.—The low rainfall and lack of surface water render this vegetation unsuitable for cultivation. Such cultivation as exists is on a small scale where water is obtainable. A large irrigation scheme is now being carried out to render the water of the Vaal and Hartz Rivers available for cultivation in the valley.

The region is essentially a grazing one of the ranching type. The southern and drier parts are used for sheep. The more grassy areas are devoted to cattle. Dairy farming is the most important industry. Owing to lack of water and the frequent poverty of the pasturage no form of close settlement is possible. The farms are widely separated and the number of cattle per unit area is not large.

A portion of the *Acacia giraffæ* Savanna has been made a forest reserve, but beyond protection of the area from fire no development has occurred.

GENERAL COMPARISON OF SAVANNA TYPES

The four types of savanna vegetation that occur in the country represent the reactions of one general structural type to different climatic environments. The Low Veld is the most luxuriant and is in the most tropical conditions : the trees are larger and closer than in any of the others. This and the Bush Veld are very closely allied, both in structure and in flora ; the Bush Veld is a simpler and drier type. On the eastern mountains it forms an extension of Low Veld vegetation to cooler conditions ; in some places it may occur as a quite narrow zone between the tropical vegetation in the valleys and the grasslands on the exposed ridges.

The simpler communities of the Bush Veld, (Small Tree Savanna and Scattered Bush) have many features in common with the Temperate Savanna, and no really sharp boundary can be drawn between them. In its typical form this last is distinguished by the bush habit and the characters of the field layer. The distinctions between

the two are, however, largely floristic and geographical. The Temperate Savanna has a considerably less varied flora, especially among the trees, which is correlated with its extension into much less tropical conditions than any of the other types of savanna.

The Bush Savanna, which is the reaction to semi-arid and decidedly continental conditions, has been studied much less than the others. Neither its characters nor its boundaries have been at all clearly defined in accounts of the vegetation: the most complete account is by Pole Evans (1920), where the vegetation is divided on floristic and geographical characters. Pole Evans' divisions, however, have not been upheld in later accounts and do not correspond to those recognised here. The Bush Savanna is here looked upon as part of the vegetation of the Kalahari region, most of which is in the Bechuanaland Protectorate. Floristically there is close affinity, much more than there is with the Bush Veld which adjoins it on the east. This floristic affinity, together with the structural characters, separates this type from the other kinds of savanna. Even those divisions such as the *Acacia giraffæ* Savanna and *Acacia* Bush, which approach the Bush Veld communities in structure and in the deciduous habit, are separated at once by the sparse, open character of the field layer and the great abundance of annuals.

The details of the relationships of these four types to the communities occurring in the territories north of the Union need not be entered upon here.

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See also Nos. (2), (3), (20) in References to Chap. IV, and (1), (2), (3) (Chap. VI).

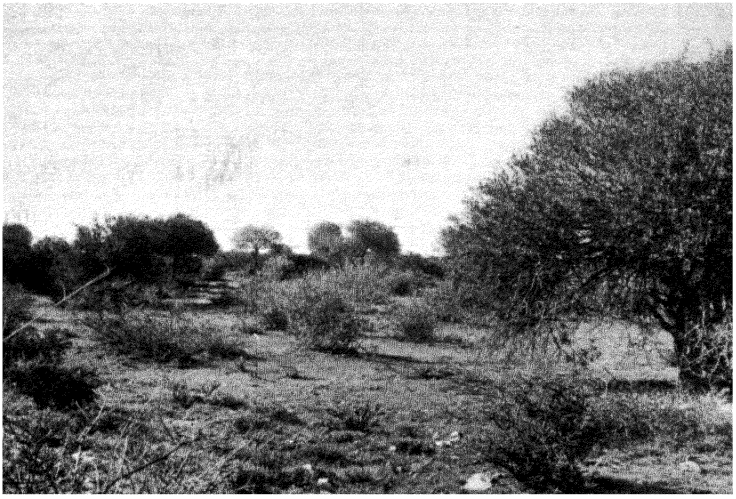
CHAPTER VIII

GRASSLAND VEGETATION

GENERAL

GRASSLAND in South Africa is an extensive and very uniform type of vegetation, uniform in structure, in general features, and also in habitat requirements. As climax vegetation, grassland covers the central part of the plateau, extending over the southern Transvaal, the greater part of the Orange Free State and portions of the north-eastern Cape. The boundaries of the Grassland area are partly climatic and partly topographic ones. Northwards this vegetation extends to the foot of the Magaliesberg, and further east to levels at which increasing temperature limits its dominance. On the high ground of the mountains of the eastern escarpment grassland covers all areas over 4,500 feet (1,370 m.). Outliers of grassland occur on the higher ridges rising in the Bush Veld country. In the east this type extends beyond the escarpment and covers the higher ground in the south-eastern Transvaal, Zululand and northern Natal. It extends to the higher ground on the western borders of Swaziland. In Natal, grassland is the dominant vegetation over 4,000 feet (1,220 m.), and may descend to 3,500 feet (1,065 m.). In the south the boundary is set by decreasing rainfall, 15 inches (38 cm.) marks the driest conditions possible. The boundary runs along the northern rim of the Orange River valley and through the western parts of the Orange Free State. In the north-west corner of the Grassland region high temperatures in summer set the limit to its extension where the rainfall is 18 inches (45 cm.).

Outside this region there are patches of grassland at higher altitudes; for example, it occurs on the southward extension of the plateau which runs into the south-eastern Cape to the Katberg and Amatola Mountains. The whole Grassland area is high in altitude and, except for the mountainous parts, has a rolling and not much dissected surface. It is traversed by valleys, but these are not



PHOT. 12. – BUSH SAVANNA near Kuruman, Cape Province. *Olea* Community on soil with lime near the surface; winter. *Olea verrucosa*, *Tarchonanthus camphoratus*, *Acacia stolonifera*, etc., ground layer open with *Pentzia* sp. and annuals.

PHOT. 13. – GRASSLAND near Brandfort, Orange Free State. Grass Veld in winter. *Themeda triandra* dominant. The dark line is a stream with trees, the clump of trees in the background is at a farm.

[*Facing p* 164.

steep or deep. This region is often referred to as the " High Veld," and the term, originally geographical, has been transferred to the vegetation.

Grassland vegetation occurs under rather sharply defined climatic conditions. The rainfall is mainly in summer ; only 20–25 per cent. of the total falls in the six winter months. Much of the winter rain, too, is in the form of light showers that have little effectiveness for plants. The amount of rainfall varies between 15 inches (38 cm.) and over 80 inches (200 cm.). A general average for the central region is between 20 and 60 inches (50–150 cm.). The temperature range is large. In summer the temperature, though lower than in the savanna vegetation in the north, is moderately high, but falls, often very rapidly, in winter. In the dry winter months radiation in the very clear atmosphere is intense and frosts are frequent and severe, though not prolonged.

The dry winter with very prevalent frost is a definite and constant feature of the grassland environment. The liability to frost is very often the determining factor at the boundaries. Though the frosts are frequent the ground does not become frozen, as is the case with the American prairies, with which many comparisons have been made. Even in winter the temperature rises rapidly in the daytime. The coincidence of dryness and low temperature almost completely limits plant activity to the summer months and results in a very decided change of aspect with the season. In summer the whole is green and flourishing, but in winter the landscape is pale brown and dead-looking. Temperature and moisture factors prevent the growth of bushes or large plants ; the vegetation is made up of herbaceous plants of uniform size.

Within the Grassland several kinds of community can be recognised. These are :—

1. Grass Veld (or High Veld Grassland).
2. Dry Grassland.
3. Moist Grassland.
4. Montane Grassland.
5. *Protea* Grassland.
6. Riverside and Valley Communities.

These divisions are dependent on differences in the habitat factors, and especially those of rainfall and temperature. While distinct in their typical forms, they are connected one with another

by all stages of transition. In a stretch of country without marked topographical features sharp changes in the factors are not to be expected.

GRASS VELD OR HIGH VELD GRASSLAND

This is the most extensive and may be regarded as the central type of grassland. It occupies those portions of the Grassland region where the rainfall is 20–40 inches (50–100 cm.). The plant cover is definitely dominated by grasses and forms a waving sheet in summer which stands 2–3 feet (*c.* 0·6–0·9 m.) in height at the flowering period. In winter the cover is quite low. A detailed examination reveals the fact that only rarely do the grasses form a really continuous turf. They grow in clumps, with perennating shoots on or just above the surface of the soil, only occasionally below it. The grass clumps are low and spreading, not densely tufted. While the spread of leaves and branches gives a complete cover in summer, the perennial bases of the clumps are not in contact but in winter show spaces between.

In typical, undisturbed Grass Veld the dominant plant is *Themeda triandra*, which may occupy anything up to 65 per cent. of the total area. This grass forms loose, superficial clumps, but its habit varies with local soil conditions. On loose, deep soils it grows luxuriantly and produces long leaves and inflorescences which reach as much as 3 feet (0·9 m.). The general effect in an area covered by this kind of grass is green in summer, changing to a coppery brown in autumn. In contrast to this, on close-grained or shallow soil, *Themeda* flowers much less freely, is lower in growth, and does not attain a height of more than 18–24 inches (45–60 cm.). The foliage is a glaucous green and does not change colour in autumn. These two facies, which differ in the form of the dominant plant, have been distinguished by farmers. The term " sour veld " is applied to that with the tall colour-changing form, while " sweet veld " is applied to the blue lower form. This differentiation has no relation to soil reaction but depends on the grass. The two forms are different in palatability to stock. The glaucous low-growing one makes a better autumn fodder.

Themeda is the general dominant, but by no means the only grass forming the community. It is associated in varying proportion with other grasses.

In damp places tall grasses become abundant, while more tufted ones are common in the drier parts. Associated with the dominant grasses are many herbaceous perennials: these include geophytes, rosette plants, plants with creeping stems, and a few half-woody plants. All are of seasonal activity and for the period of their maximum growth may become very prominent. Annuals are few in number and never abundant; perennial shrubs are typically absent.

Within this *Themeda* Grassland many subdivisions with differences in floristic composition occur, but as they all agree in the general features of structure they need no elaboration.

On the slopes running up to the eastern mountains a grassland of a somewhat different structure occurs, still with *Themeda triandra* as the dominant. The growth is more tufted, and in winter such places have a much more irregular surface. The tufts are usually separate from one another, with the intervening parts covered by low-growing grasses. In this tufted grassland the numbers of the associated plants other than grasses are fewer.

Over most of the plateau the surface is broken at intervals by steep-sided koppies of varying height and extent. These elevations have shallow soil. They are often distinguished by the presence of bushes and woody undershrubs, which are otherwise absent. *Zizyphus mucronatus*, *Rhus* spp., *Royena* sp., *Asparagus* spp. are common examples; *Melolobium canescens*, *Aloe* spp. and others occur as smaller plants. The grass on these koppies is less thick and lower in growth. Apart from those in this sort of situation larger bushes or trees are confined to riversides. In the normal grass vegetation none of the plants present overtop the grasses, which together make up 70–80 per cent. of the plant cover, so that as far as the eye can see the vegetation appears unbroken and uniform.

DRY GRASSLAND

In the regions of lower rainfall on the western and southern margins of the Grassland area the vegetation is rather different. There is a less luxuriant growth: the height in summer may be as great, but the chief grasses are in much firmer, closer tufts and have narrower and harder leaves. In winter the cover is often shown to

be really open. All stages of gradation occur, from typical *Themeda* Grass Veld to these drier communities, which themselves form a series of decreasing luxuriance. In the rather more favourable conditions, where the rainfall is 18–22 inches (45–55 cm.), the grass cover appears quite continuous in summer and very nearly so in winter, but it is harder and darker than the Grass Veld. The dominating grasses are *Eragrostis* spp. and *Sporobolus* spp., with often a large admixture of others. There are larger numbers of other plants, some of which are undershrubs and prominent in winter time. In still drier conditions, 15–18 inches (38–45 cm.) rainfall, the grassland becomes much more open. The tufts are quite separate, with bare soil between. *Aristida* spp. are generally dominant, though other grasses occur at times in equal or greater quantities. Small undershrubs, *Chrysocoma*, *Pentzia*, *Selago* and others, are abundant in the driest places.

In the drier parts the topography is more varied, and rocky koppies with bushes and succulents are rather frequent.

MOIST GRASSLAND

This type of community is found where the water supplies are especially large. It is best developed in the well-watered valleys running into the higher mountains, where the rainfall is heavy and deep soils are formed. In such situations the grasses are tall and strong-growing, little or not at all tufted. Such grasses as *Andropogon nardus*, *Hyparrhenia filipendula*, and others with similar habit, become dominant. They may reach a height of 3–5 feet (0·9–1·5 m.). In the most luxuriant parts these tall grasses form a very dense layer; at other times they are more separated, and *Themeda* and many of the grasses associated with it in the Grass Veld, occur as an under stratum. In the damper valleys the tall grass communities often have shrubs scattered through. *Acacia* and others occur, though not very abundantly.

Another moist grassland community occurs on less wet soils in the valleys on the east side of the mountains. This is a deep luxuriant meadow-like grassland up to 4 feet (1·2 m.) in height. The grasses are not tufted and are much softer, with less stem growth than the *Hyparrhenia* communities. The dominants are *Panicum* spp., *Tristachya* sp. and *Digitaria* spp., with others in lesser quantity.

The grasses here are completely dominant, and almost the only plants associated with them are tall monocotyledons, single-stemmed herbs and a few creeping plants.

The general structure of the tall-growing Moist Grasslands exhibits similarities to and alliance with the grassland communities of more tropical regions.

Montane Grassland (Tussock Grassland).—This is the type found on the higher parts of the mountains from 5,000 feet (1,525 m.) upwards. The rainfall is heavy and the temperature lower. The winters are cold but less dry than at lower levels. The dominant grasses in this type are low-growing and tend to form dense tussocks of rather small size. The tussocks may be close together so that the appearance of a uniform sward is given, or may be spaced out to give an uneven surface. Many of the tussock-forming grasses have broad flat leaves. The tussock form is shared by a number of different species which take part in the building up of the communities. Associated with these grasses are many other plants growing between. Where the tussocks are spaced out the associated plants may be very abundant and take a larger part in the building of the vegetation than in other grassland types. Included among these plants are geophytes and rather numerous undershrubs or plants woody at the base. Of the last composites are especially abundant. *Erica* spp. are very common on rocky ground.

At rather lower levels the tussock form is less prominent. The dominating grasses grow close to the soil level, with their rather broad leaves spreading, or they may form low tussocks, and they often do not occupy more than 60–70 per cent. of the surface. Along with them are numerous other plants, scapose and other herbs, and undershrubs, some of which may locally be so abundant that they are more prominent than the grasses themselves ; examples occur in *Pteridium aquilinum* in sheltered places, and *Metalasia* sp. on shallow soils.

On the highest and most exposed summits grasses are absent or confined to hollows where there is more soil. A community is formed in which undershrubs and herbs are predominant, *Erica* spp., *Helichrysum* spp., and a number of others. The great majority of the species forming these mountain top communities also occur in the typical Montane Grassland, and it would seem that a develop-

mental phase is here existing under conditions where advance is prevented owing to the exposure and lack of soil.

The Montane Grassland communities are connected with those of the Grass Veld by all stages of transition in intermediate conditions of environment. The detailed relationships of the Montane communities to the minor factors of the habitat have not been worked out.

PROTEA GRASSLAND

On the steeper slopes in the upper parts of the mountains a community is present which is distinguished by the presence of shrubs or small trees scattered through the grassland. The most abundant of these are *Protea abyssinica*, *P. roupelliæ*, *P. lanceolata*. Less common are *Encephalartos* sp., *Leucospermum gerrardi*, *Faurea speciosa*, *F. saligna*, etc. These larger plants are widely scattered and never form a continuous layer. Below is a grassland which shows all gradations, from the Montane Grassland at the higher levels to *Themeda* Grassland at lower ones. *Protea* Grassland is restricted to steep slopes, where it owes its existence to lessened liability to frosts. In its structure, and in this relation to frost, it is allied to the savanna communities and is probably an outlier of one of them.

As it is geographically so closely associated with the grasslands, and is found in places quite away from other savanna vegetation, it is included here.

RIVERSIDE AND VALLEY COMMUNITIES

These are included here because they are so much associated with the grassland geographically. Structurally they are quite different, being communities with trees or bushes.

Along streams a fringe of woody plants occurs which often stands out as a conspicuous feature in the wide-spreading low grassland. The number and size of the trees depends on the permanence and amount of water. Where water is at all times available *Salix capensis*, a deciduous tree with reddish twigs, is often abundant; other common bushes with it are *Acacia karroo*, *Asparagus* sp., *Rhus* spp., *Zizyphus mucronatus*; *Combretum erythrophyllum* is common in the northernmost parts, but does not occur elsewhere. Less permanent streams have a few scattered bushes only.

In some of the larger valleys in the central and western parts of the grassland, bush or tree communities are more extensive. They extend over the valley and up steep banks, either as scattered bushes or in thickets, in places quite dense. These communities are developed under conditions of greater moisture and higher temperatures than the surrounding grasslands. They are really outliers of the Bush Veld or Bush Savanna types.

In the higher regions of the grassland there are no tree or bush communities at all along the streams or rivers except quite locally.

Development and Succession.—The general features of the development have been worked out more completely for the grasslands than for any other type in the country. The community dominated by *Themeda* is the natural climax over large portions and represents the culmination of a series of phases. The pioneer grasses are low, creeping forms, such as *Cynodon* and others, which are gradually ousted and replaced by *Aristida* and other drought-resisting tufted forms. These in time are replaced by communities in which *Eragrostis* is the dominant, which finally give place to the climax.

This general series, which can be traced on new soils or on abandoned cleared areas and other places, corresponds very closely with the series that would be passed through on a traverse from the western limits of the region in an eastward direction. The Dry Grasslands, which exist with 22 inches (55 cm.) of rainfall or less, thus represent phases in a succession whose further advancement is stopped by the climate. That this is so is further supported by the presence of more advanced stages in places that have especially favourable local conditions.

Even with an average rainfall as low as 15 inches (38 cm.), the *Themeda* climax can be developed in local patches where suitable conditions of shelter and soil are present.

The Moist Grassland, with the tall growth of grasses which are not tufted, may be looked upon as a stage beyond the general climax where additional moisture and less severe temperatures occur. On the lower slopes in Natal the development of this type of grassland is the forerunner of bush or tree growth, and should be regarded as a stage in the developmental series of Temperate Savanna. Very little is known of the developmental phases of the Montane Grasslands.

Modifications.—Within this region, even where the conditions of climate, soil and so forth are favourable to the development of the

climax there are large areas at the present time occupied by communities of simpler structure and formed of grasses with narrower and harder leaves. Such communities are secondary and have resulted from interference with, and destruction of, the climax. The chief factors leading to such destruction, apart from actual clearing for cultivation, are excessive grazing and burning of the grass. The composition and structure of these secondary communities varies greatly in accordance with the local conditions and the intensity of the interference. In very general terms the communities produced are similar to the earlier phases of the normal development, though not identical with them. For example, over large areas in the central parts of the Orange Free State, the true *Themeda* climax is rare and the commonly developed vegetation is a grassland of rather tufted grasses with hard and narrow leaves, in which *Eragrostis* spp., *Aristida* spp., and others characteristic of the normal development, are the dominants. That such communities are not the real stable vegetation becomes apparent in the changes that occur in those places where protection is afforded: the true climax is then developed. In one area traversed, the whole country was covered by a grassland about 12 inches (30 cm.) high at flowering time in which *Eragrostis* was dominant. Here the strips enclosed by the fences of the railway line had a much taller luxuriant growth with *Themeda* dominant. When grazing is continuous, but not excessive, a grass community dominated by *Eragrostis plana*, *Aristida juncea*, a tufted grass with narrow, hard leaves, and *Sporobolus indicus* in varying proportions is very commonly developed and can be seen over wide tracts of country. It is a community of much less value for stock than the true climax. In fact, the great majority of the secondary communities that become established have a lower value both as pasture and in actual production of grass than the climax. An exception occurs in the case of the Moist Grasslands, in which judicious burning after rain may result in the destruction of the tall rank grasses and bushes and the establishment of a *Themeda* community. This community is, however, liable to further destruction from overgrazing, and is itself easily killed by burning. Under the moist conditions the *Themeda* plants are loose and well above the soil surface and readily killed by fire unless burning is carried out when the leaves and shoots are wet from recent rain.

The examples quoted are cases in which the secondary communities are very closely similar to the stages in development, and where the interference has the effect of throwing back the succession. This does not happen in all cases; there are examples where communities of a different character become established. In part of the south-eastern extremity of the Grassland region a community, dominated by the low growing *Danthonia purpurea*, has become established on land at one time covered by *Themeda* Grassland. This *Danthonia* community is developed on clay soils in a region liable to periods of drought, which together produce conditions rather unfavourable to a ready re-development of the climax. Under the existing conditions of continual grazing, the secondary community appears quite fixed.

Where interference is more severe the grass cover becomes incomplete, and either open vegetation remains or plants other than grasses are able to increase in quantity. Some of these, and especially leguminous plants, may be quite useful as fodder for sheep or horses, though few are eaten by cattle and others are untouched by any animals. Where the grazing is severe these unpalatable plants may spread rapidly, with reduction in competition, and bring about great alterations in the vegetation. Changes of this kind are especially noticeable where the plants reach a height as great as or greater than the surviving grasses. A well-known case occurs in the Transvaal where, on overgrazed land, *Stoebe* sp. becomes very abundant or even dominant. This plant forms small wiry bushes which are not only quite useless as fodder, but which restrict the re-development of grass by the shading and competition at the surface. These *Stoebe* communities represent an extreme effect of overgrazing.

Grazing is, however, only one of the factors concerned in bringing about changes in these grasslands. Burning is also widespread, especially in the mountainous parts. In some places burning is so general that over wide stretches no vegetation exists which has not been modified to some extent. Burning seriously reduces the tussock grasses and encourages those with creeping stems or deeper perennating parts. As burning is nearly always associated with grazing the effectiveness in changing the vegetation is considerable. The object in view in burning the grass is to produce fresh shoots suitable for fodder earlier in the year. When a fire passes rapidly across

dry, dormant grassland, and destroys only the dead leaves, this object may be achieved without much damage to the vegetation. But very often destruction is more thorough and grasses, often the most valuable, are killed out.

The Dry Grasslands, with their less dense cover, are not subject to burning, but are rather easily changed in character when subjected to grazing that is at all severe. Small undershrubs, such as *Selago*, *Pentzia*, *Chrysocoma* and others, spread as the grasses are reduced. With intensive grazing these little bushes become dominant and produce an open Karroo-like vegetation. This kind of secondary Karroo Bush community is common around villages and settlements in the drier parts. There is no doubt that along the Orange River valley and elsewhere the margin of the grassland has retreated before such arid types of vegetation. The retreat is one due to interference and not to any change in conditions. The reduction of the grass cover has other adverse reactions. The soil, in the resulting more or less open communities, absorbs and retains less water. The Grassland region, and especially its drier parts, is liable to irregularities in rainfall, and this lessening of the water in the soil is apt to lead to serious loss in drought periods. There is no doubt that the effects of a series of years with less rain than the average have become more severe in the altered vegetation. The open cover and compacted soil, which results from trampling, render evaporation from the surface more rapid and run off more prevalent.

Another serious result of the opening of the cover is the liability to soil erosion which follows the reduction in binding. Such erosion has become very serious in many of the more hilly districts. The extent to which the grasslands have deteriorated owing to short-sighted interference or to attempts at over-exploitation has become a very grave problem. The checking of further deterioration and the reclamation of spoiled areas requires immediate action.

Utilisation.—The Grassland has been the most valuable type for agricultural development. The pasturage is used for the rearing of cattle and sheep, and to a less extent of horses, mules and pigs. Though the natural grass produces an abundant and fairly tall growth annually, very little is ever cut as hay. Where not grazed down it is left or burned during the winter.

Cattle rearing, which is the chief pastoral activity, is devoted to

meat production over the central grasslands, to dairy produce in the east. Sheep are very successful in the Montane Grassland and are reared in less numbers on the Dry Grassland. The increase in cattle rearing, and especially the increased grazing intensity associated with the reduction in the size of grazing areas, has been the main factor in the deterioration mentioned above. Farming practice has been changed from the ranching type to that of enclosed pastures, and the change has often been without any care for the vegetation. Some attempts are now being made, and especially in the dairy regions, to increase the food value of the pastures by the introduction of grasses and other plants. Some of these are temporary crops, but others are permanent. The latter are at present on hardly more than an experimental scale. Of those tried, the most successful seem to be Kikuyu grass (*Pennisetum clandestinum*) and woolly finger grass (*Digitaria eriantha*). The Australian salt bush (*Atriplex nummularia*) has also been planted and has proved useful both as fodder and as a means of checking erosion.

The Grassland is much utilised for cultivation. It is the centre of maize cultivation. Other crops are wheat, grown in the better watered eastern parts; oats, mostly grown for hay; teff grass; potatoes; tobacco; and less amounts of Kaffir corn, rye and vegetables. Fruit-growing is not generally successful owing to the prevalence of frost.

Afforestation and Planting.—The Grassland is naturally treeless. Owing to the severe frosts and seasonal rainfall it is not favourable for afforestation. In many of the higher parts plantations started have been killed or seriously retarded in growth.

The only trees planted in quantity are wattles, which are grown for the bark as a source of tanning materials. Wattle-growing now forms an important industry, both as a source of wealth and of employment. Wattles are grown on the eastern side of the escarpment in Natal and the south-eastern Transvaal in a rather well-defined zone, locally known as the "mist belt," owing to the prevalence of fine misty rains. This belt is between 3,000 and 4,500 feet (915–1,370 m.). Wattles are grown outside the limits of this zone where conditions are suitable; some plantations occur at 5,000 feet (1,525 m.) or over, but where frosts are severe they do not flourish. Many of the plantations at higher levels, especially those near or on the edge of the plateau, are stunted and the trees make

poor growth. The wattle zone is chiefly in the Grassland, but it descends at its lower limits into the region of the Temperate Savanna. Within the zone the plantations are often so numerous that they make a very definite feature of the landscape.

In 1930 a total of 492,300 acres was planted with wattles, of which amount 380,338 acres were within the province of Natal. The species of wattle most commonly planted is *Acacia mollissima*, the black wattle. The green wattle, *Acacia decurrens*, is also grown, but to a much smaller extent. The latter species is more resistant to the attacks of bagworm (*Acanthopsyche junodi*), which has caused very serious damage to the plantations from time to time, but the tan extract contains more undesirable "red units."

The wattle bark is exported as such, or as tan extracts. The proportion of tan extract exported to the total exports is steadily rising.

TABLE 29.—*Exports of Wattle Bark*

	Quantity (long tons).		
	Bark.	Extract.	Total Value (£).
1924 . . .	90,519	15,220	840,772
1927 . . .	94,004	15,501	1,159,652
1932 . . .	56,761	18,695	492,860
1936 . . .	74,165	34,235	776,985

The wattles are grown on a short rotation, six to eight years. The plantations are clear felled. After removal of the bark and such wood as is wanted, the remainder of the brushwood is burned on the ground and a new crop started by sowing. Sowing is generally in rows, as this gives a plantation much easier to manage than the irregular result of broadcast sowing. Natural seed regeneration is only occasionally employed for the same reason.

While the trees are planted for the value of the bark, the wattles provide a very good source of much needed firewood. The plentiful supplies available from these plantations have enabled farmers to develop mechanical aids that assist considerably in production and in handling generally.

The extent of plantations of other trees is not large. Certain species of *Eucalyptus* have proved suitable for growth under the conditions present, and have been established both as plantations and as shelter belts. Conifers are not generally successful; the Mediterranean pines and the much favoured Californian *Pinus*

radiata are rarely satisfactory. Some pines from the higher mountains in Mexico and from the Himalayas have been introduced and appear more suitable. They are being tried experimentally in small plantations.

Of other trees planting has been quite local. Poplars (especially *Populus canescens*) are often grown in small groves near farms. Poplar wood gives a certain return from sale for match-making, in addition to the value as a shelter belt. Poplars and some other trees have been shown to have a definite value for the reclamation of eroded areas where dongas have been formed. *Robinia pseudacacia* and Australian Salt Bushes are also recommended for this purpose. The former provides suitable material for fencing posts and the latter can be made use of as a fodder plant.

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See also Nos. (1), (2) in References to Chap. VI and (2), (10) (Chap. VII).

CHAPTER IX

SEMI-DESERT VEGETATION

GENERAL

THIS is found in the arid parts of the country which have an average rainfall of less than 12 inches (30 cm.). Such regions are characterised by open vegetation ; they are treeless and covered by scattered shrubs of small size. The general height of the vegetation is often not more than 10 12 inches (25–30 cm.), and large areas of bare soil commonly occur between the plants.

Country with these general features covers a large area in South Africa, indeed, about a third of the whole. Of this portion no less than 131,000 square miles, or 27 per cent. of the total area, has a precipitation of 10 inches (25 cm.) or less. Practically the whole of the arid area is in the Cape Province.

The arid area is not by any means uniform or continuous. It falls into two separate parts, a very large inland area which forms a part of the plateau of southern Africa, and a much smaller coastal strip, low-lying, extending along the west coast from St. Helena Bay northwards. The inland portion is bounded on the south and west by the coastal ranges of mountains, on the east by the foothills of the highlands of the eastern Cape Province, and on the north by the Orange River valley. Arid conditions extend north of the Orange River into South-West Africa, and, within the Union boundaries, into Gordonia in the north-west.

This great inland region is generally termed " The Karroo," a name derived from a Hottentot word meaning bare or bald. The term is, however, a very general one, and cannot be applied strictly to any definite geographical region and still less to any one type of vegetation. Popularly the name is applied to the plateau regions and excludes the dry coastal strip, but it has been variously restricted or expanded. The inland dry area itself is by no means uniform either in topography or in details of climate. It can be divided into two regions, an upper one of higher altitude, 3,000–6,000 feet (915–

1,828 m.), bounded in the west and south by the mountains or escarpment which limit the drainage basin of the Orange River, and, secondly, a less elevated region, 1,500–3,000 feet (450–915 m.), which lies between the escarpment and the coastal ranges of mountains formed by the folded Cape rocks. The term Karroo has been sometimes restricted to this latter lower portion. Very commonly the two are distinguished as Upper and Great Karroo respectively. Another division is often made, Little Karroo, for the belt of dry country between the Swartberg and associated ranges and the coastal mountains.

Much the largest part of this area is underlaid by rocks of the Karroo System: the north-western part alone extends on to other types, ancient granite and associated old rocks. In Gordonia there is Kalahari sand. The surface is generally broken by endless small elevations or koppies. This dissected koppie type of surface is characteristic of the part formed by the Karroo Rocks. The granite areas are smoother, in parts very level.

The whole area is traversed by a system of drainage channels which are usually dry for the greater part of the year. Water flows on the surface, even in the main river beds, only for short periods immediately following the rains. The depth and conspicuousness of the river beds is related to the angle of slope and to the character of the underlying rocks.

While climatically the whole region is one of deficient rainfall, there are significant variations. The rainfall decreases from east to west, and inland from the coastal mountains. The coastal strip is very dry, especially in the north. The eastern parts and practically the whole of the Orange River drainage basin have such rain as there is in the summer, whereas the western portions of the Great Karroo, the Little Karroo and the dry coastal strip have a winter rainfall.

The structure of the vegetation throughout is rather uniform. The plants are low-growing, most commonly woody, and spaced out with bare areas between. Annuals are very numerous. There are, however, great variations in detail of plant form and in composition. The arid parts of South Africa have an exceedingly rich and varied flora and one which contains numbers of plants with interesting modifications correlated with the conditions of the environment. The number of species and their variety in form is probably greater

in this country than in any other part with a similar type of climate. The richness of the flora is exhibited by great variety in the floristic composition of the vegetation even though the structure remains the same. This diversity of flora has led to differences of opinion in regard to the subdivision of the vegetation. In the present account no one of the arrangements so far advanced has been followed entirely. A primary division is made on the general character of the vegetation into " Arid Bush " and " Succulent Bush " types. The latter is broadly distinguished by an abundance or dominance of succulent plants which are rare or absent in the former. These two divisions coincide in a general way with geographic and climatic features. The Arid Bush type covers the whole of the Upper Karroo, while the Succulent Bush is entirely on the lower ground, the Great and Little Karroo, which are not separable vegetationally, and the arid coastal part.

Each of the types is separable into a number of distinct divisions which represent quite different reactions of vegetation. These divisions are :—

Arid Bush (Upper Karroo).

1. Karroo Bush Community.
2. *Gnidia* Community.
3. *Lycium* Community.
4. *Salsola* Community of Pans.
5. *Rhigozum* Community.
6. Desert Communities.

Succulent Bush (Great and Little Karroo).

7. Low Succulent Bush.
8. Tall Succulent Bush.
9. Coastal Succulent Bush.

There are also distinct River Bed Communities in both types.

ARID BUSH

These open communities of small bushes without succulents occupy the larger part of the Upper Karroo, which is all over 3,000 feet (915 m.). The rainfall in the east is larger and in summer, in the west very irregular in distribution. The whole area is liable to large temperature changes and in winter night frosts are of regular occurrence.

Karroo Bush Community.—This is the most widespread of the Upper Karroo types. It covers the whole of the eastern portion and extends westwards along the high ground near the escarpment as far as the Roggeveld. This type extends south of the escarpment and covers parts of the lower plateau in the central regions, for example, in the district of Graaff Reinet and Aberdeen.

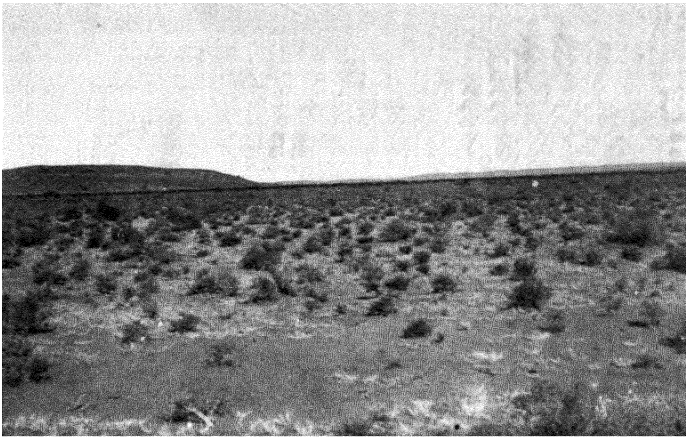
The vegetation is composed of undershrubs with very small leaves, of which *Pentzia* spp. and *Chrysocoma tenuifolia* (a small shrub with green heath-like leaves belonging to the Compositæ) are very much the commonest. These plants form low bushes 3–12 inches (7–30 cm.) high, either hemispherical or pyramidal in outline. The little bushes most often have the leaf-bearing branches raised slightly above the ground level, giving the bush some general resemblance to a short spread-out shaving brush. The bushes occur at varying distances from one another; where the rainfall is larger they are fairly close, 6–12 inches (15–30 cm.) apart, with bare soil between. In the drier parts they are much more widely spaced. In the absence of grazing or other disturbing factor the degree of separation of the bushes is very closely related to the aridity of the conditions.

For large stretches these plants form practically the only perennial constituents of the vegetation. The two dominants may occur together or in alternating pure communities. Other perennial plants are less in quantity: they may have the same general form or not. Succulents or succulent-leaved plants are local. Low-growing perennials, with stems scarcely rising above the surface, are scattered throughout but are not abundant.

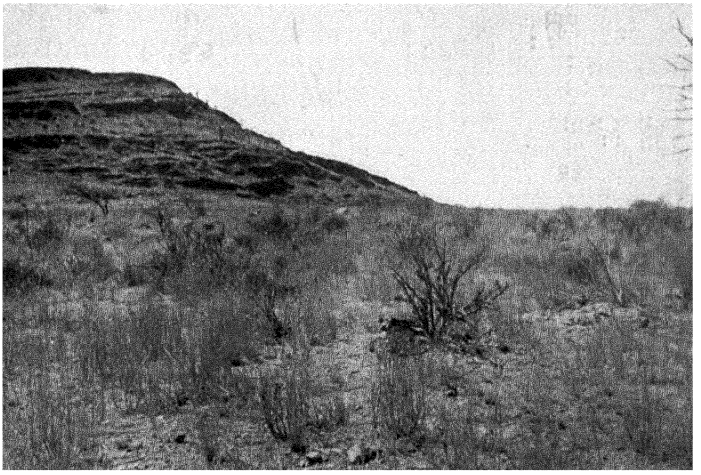
Many of the perennials exhibit a dual root system, having the main roots penetrating to considerable depths, and some lateral roots which spread horizontally a short distance below the surface. In all the plants the root-spread is greater than that of the shoots.

Annual plants make up a large fraction of the flora. They are mostly short-lived plants that appear after rains and carry through their life in a short period. Annual grasses are usually the most prominent. Where the rainfall is concentrated in the early summer the resulting growth of these grasses may be so vigorous that the perennial bushes are overtopped and temporarily hidden.

The Karroo Bush community produces a characteristic type of landscape. In the more open portions the soil colour is more



PHOT. 14. ARID BUSH near Carnarvon, Cape Province. Karroo Bush Community with open vegetation of *Pentzia virgata* and *P. globulifera*, with dead annual grasses.



PHOT. 15.—ARID BUSH near Kakamas, Cape Province. *Rhigozum* Community. *Rhigozum trichotomum* with tall annual grasses. *Aloe dichotoma* on hill behind. Photo taken in winter following a season of very good rains.

apparent than that of the plants, but where the growth is closer the predominating colour is the grey-green of the bushes. The large extent of country covered by this community is not uniform. The associated plants differ considerably in different parts, largely owing to the soil characters. In low-lying places soil, usually red, collects to greater depths, and in such depressions is level and very often has a high concentration of salts in the surface layers.

Actual efflorescences of crystals may take place at the surface. Such spots have a distinct vegetation ; the common Karroo bushes are absent or very much less abundant, and their place is taken by succulents, of which *Mesembryanthemum* (*Psilocaulon*) spp. are abundant, with *Lycium* sp. in the drier parts. Annual plants often form the only covering in these places where the soils are bare for much of the year. A very similar kind of community is found in the beds of the larger rivers where silt has been deposited. Where deeper channels have been cut, and more especially where water continues for longer periods, strips of larger bushes up to 3–4 feet (1·1 m.) in height may be found. Such larger bushes usually form only a fringing strip along the sides of the river channel, on soils that do not have an excessive supply of salts. Larger bushes or succulents are also found in more extensive communities on the sides of the steeper koppies. Such bush communities are most common in the less arid parts. The bushes form very open communities, with the low Karroo bushes between the bigger ones. Their development is correlated with the lessening of frost intensity on the steep slopes.

***Gnidia* Community.**—A rather distinctive community in which *Gnidia* (*Athrosolen*) *polycephala* is the most abundant plant occurs over much of the less elevated country in the north-central portions of the Cape Province and parts of the south-west of the Orange Free State.

Gnidia polycephala is an almost leafless branching bushy plant, 18–20 inches (45–50 cm.) high. It forms open communities in which it is either alone or accompanied by other perennial plants of the same general habit. *Pentzia* often occurs between the taller plants. The density of the community varies very much, and the number of annuals varies according to the degree of spacing of the bushes. Especially in the eastern parts of the area of this type, annual grasses are exceedingly abundant in a very scattered com-

munity of perennials. The *Gnidia* community occurs on less broken country than the Karroo Bush, and generally on deeper soils. In addition to soil differences, the lower ground occupied by this community seems exposed to less intense winter frosts than the country of the Karroo Bush type. For example, on successive clear and windless nights in July, the minimum temperatures recorded at the soil level were 17° F. (— 8° C.) in the Karroo Bush community at 4,700 feet (1,432 m.), and 30° F. (— 1° C.) in the *Gnidia* community at 3,900 feet (1,188 m.). The average summer temperatures are higher in the area occupied by this community.

***Lycium* Community.**—In the parts of the Upper Karroo west and north-west of a line drawn from Prieska to Carnarvon, the rainfall becomes less than further east and the general character of the country more level and less broken. The soils are often deeper, less stony and red or brown in colour. This level country is lower in altitude.

The characteristic vegetation in this area is dominated by *Lycium* spp. The bushes are branching, spinous and rather irregular in outline. They reach a height of 1–3 feet (0·3–0·9 m.). The plants have crowded, very small, succulent leaves. Owing to the taller habit and the dark green colour of the leaves, these communities give an appearance of greater luxuriance than the Karroo Bush community. They are often very open in character and only cover a small percentage of the soil. Annuals are generally much less abundant than in other Karroo types. Annual grasses are rarely at all abundant.

Lycium communities are confined to deeper soils ; on ridges and on stony soils vegetation of the Karroo Bush type is formed. The two grade into one another and are not sharply separated. While *Lycium* is most commonly found in pure communities, it may be associated with other plants, both succulent and other. The soils are always rather rich in salts.

Pans.—The so-called " pans " are a very characteristic feature of the more level portions of the Upper Karroo, and especially of the central and western parts. Pans are level, flat areas, occupying depressions which may be very shallow. They may be water-covered in the wet period, but for most of the year are quite dry ; they are formed of silt or clay-silt, brown or red in colour, generally with a high concentration of salts. Pans of small size occur on

almost every part of the Karroo area, but large ones are especially abundant within the region of the *Lycium* community in the districts south and south-west of Kenhardt. Here some of them are ten miles or more across. One of these, Verneuk Pan, assumed a considerable degree of prominence in the Press a few years ago when its flat surface was made use of as a speed track.

These pans are characteristically quite bare of vegetation. Fringing zones occur and plants are found on any slight elevations on the surface. The absence of plants is complete, neither perennials nor annuals occur on them. The fringe nearest the central bare part is made up of *Salsola aphylla* and *Atriplex* spp., the former, a whitish shrub with small appressed succulent leaves, being much more abundant. A little distance behind they are associated with annual species of *Mesembryanthemum* (*Psilocaulon* or *Cryophytum*), which may be very abundant. *Lycium* becomes abundant behind and on definitely raised ground.

The bare soil on these pans is not at all readily colonised by plants. Even when a pan ceases to retain water during rain the spread of *Salsola* and others over the surface is very slow. In the ordinary pan the waterlogging during rain and wind erosion in the dry periods, together with the saline soil, render establishment difficult and uncertain.

The origin of these pans is a problem not yet entirely settled. The explanation most generally put forward is that they commence from areas where water accumulates during rain, either in depressions or on flats where overflows from rivers occur. The largest pans in the Kenhardt district all seem to be associated with river channels. The standing water allows deposition of silt ; on drying this cracks and is easily removed by wind.

This wind action both prevents establishment of plants on the surface and readily interferes with surrounding vegetation and so causes an enlargement of the original pan area. The very irregular outlines of some of the pans certainly suggest such a form of enlargement under wind action or even confluence of originally separate areas. It may be noted that the larger pans are not infrequently indicated on maps as either lakes or marshes ; neither gives at all an accurate representation of the conditions as they actually exist.

***Rhigozum* Community.**—The characteristic plant in the very dry regions of the north-western part of the Cape Province is *Rhigozum*

trichotomum. This plant, which is exceedingly drought-resistant, has a habit of growth quite unlike that of most of the plants of the dry regions. It is a woody shrub with erect stems, either single or two to four from one root, which bear short divaricate branches at the ends of the year's growth. The bushes are 1–3 feet (0·3–9 m.) in height, and do not have at all the bunched rounded habit of the great majority of Karroo plants. They are loose, erect bushes, with small flat, hard leaves along the stem; leaves which become exceedingly dry but persist in the dry winter period.

Over large areas this bush is almost the sole perennial plant on the soils derived from the ancient granites in Bushmanland. The communities are most often very open in character, with large spaces either quite bare or occupied by annuals with a short active season. These annuals may persist for long periods in a dead, dried-up condition, and frequently give an impression of relatively closer vegetation.

In these communities a very common feature is an irregular distribution of the perennial bushes; in patches the *Rhigozum* bushes are fairly close, but there are large intervening tracts in which they are very scattered. While *Rhigozum* is often the only perennial, other plants do occur associated with it, and especially so towards the margins of the area occupied by the community. *Pentzia* spp., *Mesembryanthemum* spp., *Cadaba juncea*, *Lycium* spp. and some tufted grasses are among the most common. Annuals, and most especially grasses, are very abundant both in numbers and in the amount of surface covered; during their period of growth they much surpass the perennial bushes.

The country occupied by this community is a gently undulating plateau, with an absence for the most part of sharp surface features. The underlying rock is granite, though the community does extend on to parts of the Karroo rocks. The granite forms a pink-coloured soil, most often a coarse sand. The uniformity of topography and soil, together with the spare vegetation, give a characteristic type of scenery, though one that becomes somewhat monotonous owing to its continuing over large areas. Especially in the winter the pink soil, dried up grasses and the sparse, erect, dark or almost black, bushes produce an appearance very different from that of any of the other communities of the Karroo region.

The north-western part of the Cape Province, where the *Rhigozum*

community is developed, is about the most arid part of the country, and the conditions are evidently near the limit of those possible for general distribution of perennial plants. Within this area the actual distribution of communities is very sharply divided, according to the features of the soil. The *Rhigozum* community, which is very much the most widespread, occurs on the pink granite soils and rather shallow soils derived from dolerites or some of the harder Karroo rocks, but within its area the presence of other kinds of soil results in a quite different plant community. Thus outcrops of hard quartzitic rocks bear a low open vegetation of *Pentzia* and *Mesembryanthemum*. Rocky koppies, formed by outliers of Karroo rocks, have a vegetation of small bushes or succulents, among which the large *Aloe dichotoma* (Koker boom) is often very abundant. These koppies are distinguishable not only topographically, but also by the soil, which is grey instead of the prevailing pink. The vegetation is very sharply delimited, so much so that a line can be drawn which separates one type from the other and coincides with the line of junction of the rock outcrops.

Of these soil-distinguished communities, one of the best marked and also the most widespread is developed on areas covered by loose and often mobile red sand. This sand, which is a southern extension of the Kalahari sand, is much finer than the pink granite soil and is of a deep red colour. These sand areas form systems of elongated dune ridges and hollows and bear a quite distinctive vegetation. *Rhigozum* does not extend on to them at all. They are covered by an open community of *Aristida brevifolia*, "toa grass," which most often forms a quite pure community with no other associated plants at all, either perennial or annual. The absence of any growth of annuals, and the consequent exposure of large parts of the red sand, renders the areas of the community very conspicuous and easily recognised, even from long distances.

Aristida brevifolia is a low shrub-like plant with the perennating shoots branched above ground, persistent, and bearing very small leaves. In the dry season, when no inflorescences are present, the bunched tufts have an appearance much more like that of a dicotyledonous shrub than that of a typical grass. These toa grass communities on the red dune sands may cover quite large areas and formed one of the more serious difficulties to the older travellers through the area on account of the loose soil and the complete

absence of water. Even under modern conditions this vegetation is one preferably avoided.

Around the margins of these areas of red sand, and to some extent in the hollows between the dune ridges, some characteristic plants are found associated with the Toa grass. One example only may be noted, *Parkinsonia africana*, which is a deciduous shrub or small tree, 5–8 feet (1·5–2·4 m.) in height, whose presence in hollows gives an illusory appearance of luxuriance and possible water supplies.

Desert Communities.—In the driest regions towards the lower part of the Orange River valley, where the small rainfall is accompanied by high average temperatures and very high temperatures in the summer, perennial plants are either very scarce or even totally absent. Annual plants are present in numbers varying with the amount and distribution of rain from year to year, but are of short duration. In the dry season large areas are quite bare or carry a thin covering of dead annuals.

These desert areas are of limited extent within the boundaries of the Union, too small to be indicated on a small-scale map. They represent the southern margin of the desert area which occurs in the coastal part of South-West Africa, the Namib, which extends northwards from the Orange River.

River Valley Communities of the Upper Karroo.—Excluding the communities fringing the few permanent rivers which have constant water supplies available, distinctive communities occur in river valleys, and more especially in the larger valleys, which are sufficiently extensive to warrant some description.

Dwarf *Acacia* Community.—A community in which the most abundant and characteristic plant is *Acacia detinens* occupies the valley sides of the depression of the Orange River and its tributaries in the region between Prieska and the Aughrabies Falls. The community, which is strictly confined to the valleys, is an open one. The *Acacia* forms bushes or small trees varying in height from 4–6 feet (1–2 m.) down to 12–18 in. (30–45 cm.). The size of the bushes varies with the depth of the valley and the distance of the plants from the valley bottom. In these open *Acacia* communities other woody plants may be quite absent or occur along with the characteristic species in varying numbers. *Rhigozum trichotomum* is common in the western parts; *Euryops multifidus*, *Gnidia polycephala*, *Lebeckea macrantha* and others in the upper reaches. Other

common plants are *Aloe* sp., *Pentzia* sp., with grasses and other annuals and a few perennials. Immediately along the beds of non-permanent tributary valleys other plants occur, of which *Zizyphus mucronatus*, *Acacia karroo* and *A. giraffæ* are the most common. The two last may attain the stature of trees.

This Dwarf *Acacia* Community is one definitely demanding greater quantities of moisture than are generally present in the Karroo area. It does not extend on to the open plateau at all. Ascending from a river bed the *Acacia* bushes become smaller, and towards the rim of the valley cease and are replaced by the plants of one or other of the communities described above. This Dwarf *Acacia* community shows a number of features, both structural and floristic, in common with the Bush Savanna type, and is probably best regarded as a transitional type between that and those of the typically arid conditions.

***Boscia* Community.**—This community, which is also a valley type, is found in the drier parts west of the limits of the Dwarf *Acacia* Community. It occurs in the Orange River valley below the Aughrabies Falls, extending some miles west of Pella. The characteristic plant here is *Boscia* sp., which typically forms a small rather umbrella-shaped tree, that may attain a height of 6–8 feet (2–3 m.). These trees are most often very thinly scattered through vegetation that is otherwise indistinguishable from that occurring outside the valley. The *Boscia* trees may be long distances apart and, though giving a distinctive appearance, really scarcely constitute a separate kind of vegetation. Locally, however, they may become quite abundant, and there some characteristic species occur associated with them which are not found in the communities around. *Hermbstædtia glauca*, an erect twiggy, almost leafless, shrub belonging to the Amarantaceæ, may be mentioned as one of these which is locally very abundant.

Summary of Arid Bush Vegetation.—The communities of the Upper Karroo are distinguished from one another in structural, geographical and climatic features. Excluding those confined to river valleys, they form and can be placed in a series representing progressive degrees of aridity. The Karroo Bush community is that demanding the highest degree of moisture. It is the general type in the eastern parts where the rainfall is more abundant and more regular. In the western parts it is confined to the higher

ground. The *Gnidia* community occurs under conditions rather drier and with lesser temperature extremes in winter. The *Lycium* and *Rhigozum* communities are those of definitely more arid conditions.

The *Rhigozum* community, with its associated soil types, is distinctive in structure, and especially in its floristic characters. The flora of Bushmanland has decidedly more affinity with that of South-West Africa than with that of other parts of the Karroo area, and it is probable that this community is really part of the vegetation of the desert area further north, and quite distinct from the Karroo Bush type and its associates. The flora of the latter is certainly closely related to that of the surrounding regions with better rainfall.

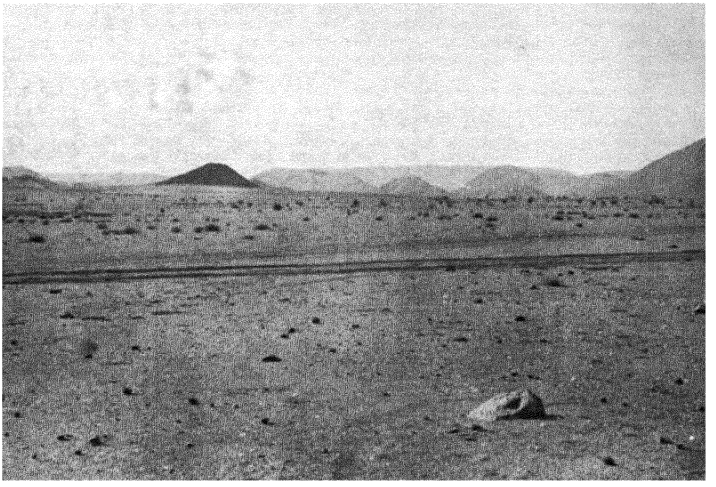
It is doubtful if the *Lycium* community, which is rather distinctly soil-limited, has quite an equal status with the other communities described. In flora and habitat it is more allied to the *Rhigozum* type than to the Karroo Bush. Until more knowledge is attainable on its successional relations, its wide extent justifies the retention of it as a separate unit.

SUCCULENT BUSH

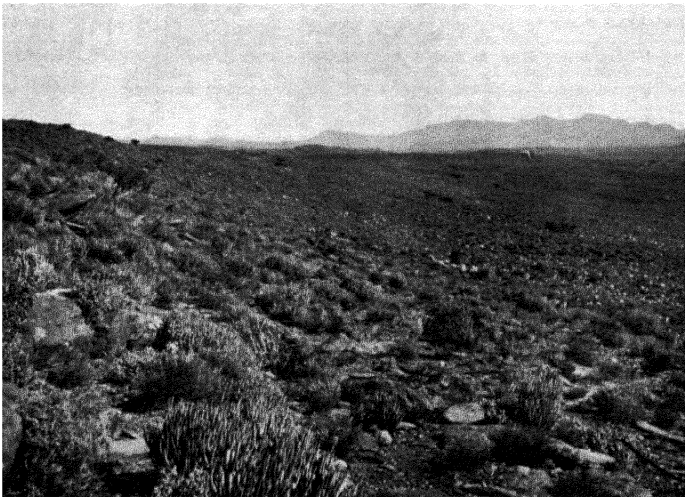
This type occupies less elevated country which has less severe winter frosts. It is characterised by the general abundance of plants with water storage. The size of the plants varies, but succulent characters are very common and never wholly absent.

Low Succulent Bush.—The general type of Low Succulent Bush covers a wide area, extending over the Great Karroo from the valley of the Sundays River westwards. The northern and southern boundaries are formed by the escarpment of the Upper Karroo and the coastal ranges of mountains. In the north-west the boundary is the watershed separating the basin of the Orange River from that of the Doorn River. The community also occupies the drier parts of the Little Karroo and is found on the slopes between 2,000 and 3,000 feet (610–915 m.) in Namaqualand.

The dominant plant form here is a low bush, typically dense and more or less hemispherical, 2–8 inches (5–20 cm.) high, and usually with succulent leaves. There may be aerial branching stems, or if not the leaves are tufted. Of other plants species of *Mesembryanthemum*, in the wide sense, are much the commonest over most of



PHOT. 16. ARID BUSH. Desert Community near Goodhouse, Cape Province. Soil almost bare, save for tufts of annual *Pentzia* sp. and a few bushes of *Stipagrostis spinosa*.



PHOT. 17.—LOW SUCCULENT BUSH near Whitehill, Cape Province. *Euphorbia mauretanica* with *Mesembryanthemum spinosum* (right) and *Crassula perfossa* (left), etc.

[*Facing p.* 188.

the area. Additional species, both succulent and not, also occur and may replace the dominants.

The general life-form is rather constant; ericoid bushes are present in smaller quantities than those with succulent leaves. Taller bushes, either succulent or otherwise, are most often quite absent.

In this Low Succulent Bush annuals are abundant, though they form a much less conspicuous feature of the vegetation than in the communities described for the Upper Karroo. The annuals are small in size and, though often showy, rarely overtop the perennials. Grasses are common in the eastern parts, but rare elsewhere. There are a number of geophytes which have a short active season; these are specially common in the western portion with winter rainfall. In the drier parts the plants are all of small size and widely scattered, while where there are greater supplies of moisture available the growth may reach as much as 2 feet (60 cm.) and is closer. The composition varies greatly from place to place; indeed lists from different spots often exhibit a very small percentage of species in common. On the other hand, the life-form and structure are so uniform that these local communities can only be separated floristically. Some of the "sub-communities" are related to changes in the soil and the transition from one to another may be very abrupt. Some of them are the result of the presence of large numbers of species with very restricted geographical range. Within its area a species may be very abundant, while outside it is replaced by another, often with the same life-form.

Tall Succulent Bush.—This is readily distinguished from the foregoing types, both in life-form and characteristics of its habitat. The vegetation here is built up largely of tall-growing succulent plants, often over 3 feet (0·9 m.) in height. These plants form larger, looser bushes, and together give an appearance of much greater luxuriance than the other communities of the arid regions. In many cases the upper parts form an almost complete cover. Various species of *Euphorbia* (especially *E. mauretanica*), *Cotyledon*, *Aloe*, *Crassula*, *Mesembryanthemum*, *Portulacaria*, and others are very characteristic in this vegetation. These succulent plants are always associated with a number of non-succulents. Some of them are large bushes and many are spinous. *Euclea undulata*, an evergreen bush or small tree, often umbrella-shaped, bearing hard, dark leaves, is especially common. Very numerous smaller plants occur

beneath and between the larger ones. Annuals are less frequent than in the Low Succulent Bush. Tall Succulent Bush forms the habitat of a number of the more interesting and curious types of succulent plant. There is considerable variety in composition in different places, but throughout a close similarity in structure and plant-form. The type is developed in conditions less arid than those of the Low Succulent Bush and less liable to frost. It is most characteristically developed round the margins of the dry areas, and is especially common on rather steep slopes on the foothills of the dividing mountains. On such slopes frost frequency is reduced. In its most characteristic form the community is confined to those parts of the Karroo which receive winter rainfall. There are, however, some examples in the summer rainfall portions which seem most naturally associated here. In the eastern part of the Great Karroo, near Jansenville for example, there are extensive communities in which *Euphorbia cærulescens* is very abundant or even dominant. This plant forms tufts of leafless, succulent, spiny stems rising to 3 feet (0·9 m.) in height. The associated plants are mostly not succulent.

The Tall Succulent Bush is a type that is transitional in its habitat requirements between the Low Succulent Bush, on the one hand, and the driest parts of the Sclerophyll on the other. Every stage of gradation can be traced in each direction. The transition zones may be broad or rather abrupt. The most extensive areas of this type are in the Little Karroo, in the isolated arid area near Robertson, and on the western slopes of the mountains in Namaqualand at about 3,000 feet (915 m.). In the northern parts of Namaqualand this community grades into the *Aloe dichotoma* type associated with the marginal zones of the desert areas.

Coastal Succulent Bush.—The vegetation here, both in structure and plant form shows many features in common with the Tall Succulent Bush. It is met with along the low-lying arid belt on the west coast which is both arid and frost-free; temperature fluctuations are small, and much less than inland, while the winters are warmer and the summers cooler. The rainfall is in winter. The arid coast belt extends from St. Helena Bay northwards to the mouth of the Orange River. There is a considerable range of conditions within this belt; in the south there are 10 inches (25 cm.) of rainfall, whereas in the northern parts the amount falls to 2 inches

(5 cm.). The vegetation shows a corresponding range from rather luxuriant types to very open desert-like ones. It is in the more favoured parts that the similarities to the Tall Succulent Bush are most apparent. These similarities comprise an agreement in the general plant-form and some community of actual species.

Throughout the region the succulent life form, and especially the taller succulent plant, is abundant. In the central parts open communities composed of bushes 2–3 feet (60–90 cm.) high, with numerous annuals and geophytes, are developed. The larger plants are predominantly succulent. Small succulents are also abundant between the larger ones. The strong growth of the taller succulents often gives an appearance of greater luxuriance than is the case with corresponding moisture conditions inland. Within the belt are many local communities dependent on local soil and other factors.

River Bed Communities.—The river beds are often lined by bushes or small trees which form a striking contrast to the low surrounding vegetation. *Acacia karroo* and *Rhus viminalis*, a small tree with pendent branches and trifoliate leaves, are the most common trees. They are frequently associated with bushes of various kinds. The trees may form a mere fringe or, along the larger rivers, more extensive communities. Where the trees are abundant the ground below them is bare or carries a few short-lived annuals.

Where deposits of silt have occurred in the river beds a characteristic community of *Salsola aphylla* is found. This may be associated with trees but more commonly is not. The community is often quite pure with no associated plants.

Modifications.—Though the population of the arid regions is small and scattered a considerable amount of alteration to the vegetation has been brought about. Grazing has been the chief modifying factor.

A zone of desert-like conditions is found round most of the towns, villages, or even isolated farms, and in the vicinity of kraals and dams or other drinking places. The destruction of the vegetation is due to eating down of the plants and to trampling of the soil, which interferes with the growth of annuals. In those parts where ostrich farming was or is carried on this elimination of vegetation is very pronounced. In these parts, even though the number of birds has been reduced to a small fraction of what it was ten or fifteen

years ago, large areas have still no vegetation or only a temporary cover of annuals and weeds.

In these arid regions the vegetation is living under conditions often very near the limit of possible survival. Even under normal and natural conditions a reduction of rainfall for two or more years in succession may cause a considerable mortality among the plants. If any added destructive factor is present large effects may be produced very rapidly. Where grazing is not intense the effect is an increasing sparsity of the bushes and a reduction in the annuals. Annual grasses may disappear altogether under grazing. This change may be temporary or progressive according to the amount of the grazing. One example may be noted. In the Low Succulent Bush there is at present a large area of vegetation near the railway line which has been rendered very sparse and open owing to a period of over-grazing. Numerous sheep were brought here from the north and north-west Cape province, which had experienced so prolonged a drought that the vegetation could not support the animals. The effect of this sudden increase in grazing was a severe reduction in the plant cover, both perennial and annual. The invasion of sheep took place three years ago, but there are still large areas quite bare of plants.

Regeneration of the vegetation after destruction in these arid communities is often very slow ; where grazing is at all severe there is a production of increasingly open vegetation which renders the soil liable to removal by wind.

In the Karroo Bush community the preference of the sheep for *Pentzia* brings about a reduction in this plant and often a spread of others. *Chrysocoma*, for example, often forms pure secondary communities as the result of this selective grazing. An exactly parallel case is seen in the Low Succulent Bush, where *Galenia africana* (Kraalbos), a small yellow-green shrub with narrow aromatic leaves, extends very rapidly and may assume dominance in grazed parts. When *Galenia* does become dominant regeneration is very slow, even if grazing is stopped, owing to the shading that is produced.

Another plant which has extended and spread through vegetation modified by grazing is the introduced prickly pear, *Opuntia*. This has become quite established over large areas, especially in the eastern parts of the Great Karroo, but has not spread to any extent in the winter rainfall regions. While conditions have not yet

reached the state that occurs in parts of Australia, quite large areas have become useless for grazing owing to the abundance of *Opuntia*, and serious attempts are being made to combat it. While the plant is a real pest when abundant, it has also been at times a benefit. In drought periods farmers have been able to preserve their stock by using it, freed from the spines, as fodder. This value complicates the application of methods advocated to control its spread. At the present time the spineless variety is being cultivated widely as a fodder plant. In the vast majority of the plantations a certain percentage of the common prickly form appears and it is always liable to spread through the surrounding vegetation.

At the present time a large part of the region of these Semi-Desert communities exhibits some sign of change in the vegetation owing to grazing. Over very wide areas the numbers of animals are not too great to destroy the balance when precipitation is of the average amount or above it, but when this falls below the average, growth does not compensate for the consumption.

The character of the grazing has had as great an influence in the deterioration of the vegetation as the intensity. Much of the country is unfenced but, owing to the presence of jackals, the flocks are kept herded together and the grazing concentrated in a limited area. At night the animals are collected and enclosed in a kraal. This practice means continuous severe grazing round the kraal, and soon an increasing bare, desert-like zone is formed. The enclosure of pasture areas by jackal-proof fencing, so that the sheep can remain out and can spread over a larger space, results in much better maintenance of the balance with the natural growth of the plants, by giving a more distributed and less concentrated nibbling. The conditions produced are, in fact, much more like those that existed in the original state before settlement started.

In addition to grazing, alterations have resulted from other causes. These are most apparent in the River Bed communities, where trees have been cut for firewood and either eliminated altogether or largely reduced. On the other hand certain trees have been favoured; *Rhus viminalis* has very commonly been exterminated while the spinous *Acacia karroo* persists.

Utilisation.—Semi-desert vegetation, and more especially the Karroo Bush and Low Succulent Bush types, is valuable for the rearing of sheep and goats. The numbers that can be maintained here

are small. They vary from one sheep per acre in the more luxuriant parts to one sheep to four acres. In Bushmanland, where the sheep rely for food almost entirely on the annuals, the numbers are still smaller.

Throughout the arid regions the irregularity of the rainfall, and the accompanying variations in growth made by the vegetation, cause large differences from year to year in the carrying capacity for animals. A succession of three or more years with rainfall below the average very often results in considerable losses from drought. For example, in 1929–30 the total loss of sheep and goats from drought was estimated at just over four millions out of a total number for the whole Union of 46 millions. In the arid regions the percentage losses were much greater than this. Ostriches are now kept in small numbers only.

Cultivation in these parts is only possible where there are additional supplies of water. Over much of the Karroo area water can be obtained by boring, but the amounts produced are insufficient for more than small patches which supply local needs. There are, however, a number of areas where irrigation works have been established and cultivation on a larger scale has been possible. Fruit, both citrus and deciduous, maize, wheat and lucerne are the main crops. In the case of the irrigation works at Kakamas on the Orange River, in addition to the above, cotton has been grown successfully though not on a large scale.

The irrigation on the Zak River, south of Kenhardt, may be mentioned because the system is unusual. The river has an intermittent flow; the country is flat, and when water comes down it is led from the river and allowed to spread over and soak into flat land which is to be cultivated. Earth dams ("Saai-dams") are built round the areas to be irrigated. Wheat is grown on this land. The growth is completed and the plants ready for harvesting before the ground becomes dried out.

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See also Nos. **(9)**, **(19)**, **(20)**, **(21)** in References to Chap. IV and **(9)**, **(12)** (Chap. V).

CHAPTER X

LAND UTILISATION AND NATURAL PRODUCTS

GENERAL

THOUGH the Union of South Africa has a small population in proportion to its area, the greater part of the land has been parcelled out. The only parts quite unoccupied are mountains and regions devoid of water. Land utilisation has been influenced by the historical development of the country: the natives originally came in search of new land under the pressure of competition, while the Europeans were drawn to the interior by the pioneering spirit combined with a dislike of the controls of Government. In more recent times the discovery of minerals and mining activities have caused rapid concentrations of population and induced great changes in land values and usage.

The settlement of the country and division of the land have caused changes in usage which are not altogether completed at present. In early times the natives did not have permanent settlements, but moved from place to place as areas became exhausted for cultivation or pasture. This shifting cultivation, which was necessary with the primitive methods employed, has been stopped in the general division of the land. As owners natives are now almost restricted to those parts set aside as reserves. The early settlement of Europeans was similar: very large tracts were taken and "extensive" methods of agriculture followed. As the amount of available land per head has become restricted with increasing population, the older methods are being replaced by more intensive ones. Originally a farm, whatever its size, was devoted to one object; nowadays mixed farming is slowly becoming more general.

Of the total area of 472,550 square miles, 317,991 is farmland owned or occupied by Europeans, 27,000 square miles are native reserves. The remainder is unoccupied Crown land, or land used for other than farming purposes. Of the "farmland" only 6·3 per cent. is under any form of cultivation; the rest is grazing land or

is quite undeveloped. In the ensuing section a summary of the chief aspects of land utilisation is set out.

GRAZING AND LIVESTOCK

This is much the largest agricultural activity and is carried on everywhere. The following table gives the numbers of animals in the country in 1930 :—

TABLE 30.—*Numbers of Livestock*

	Owned by Europeans.	Owned by Natives.
Cattle	6,668,092	3,905,777
Horses	646,185	189,818
Mules	127,296	2,558
Donkeys . . .	529,144	170,416
Pigs	629,831	311,973
Sheep (*a*) Wool . .	39,748,168	4,163,995
(*b*) Other . .	3,935,247	510,941
Goats (*a*) Angora . .	1,661,300	139,471
(*b*) Other . .	3,074,208	3,079,428
Ostriches . . .	31,618	—

Cattle.—Cattle are kept for beef production, hides, and for dairy purposes. They are also used for transport, but in decreasing numbers. The chief cattle regions are the Grassland, with Bush Veld and Temperate Savanna only a short way behind. The Bush Savanna has many less and the other types are only of minor importance.

Cattle are indigenous to the country; at any rate at the first arrival of Europeans the natives possessed herds of cattle. In the early days of settlement cattle were the principal transport animals and were made use of chiefly for that purpose, and cattle breeding was directed to the production of a strong and drought-resistant animal. From the native herds, crossed with imported European cattle, the Afrikander breed has been derived. With the universal use of mechanical transport the ox has lost its value for traction, and recent breeding has been concerned with improvements in beef quality. The Afrikander breed is being altered in this direction.

The greater part of the cattle in the country are of mixed breed and may be termed "utility animals." Importation of stock and careful breeding have led to considerable improvement in quality in

recent years. The most important introduced breeds are Frieslands, Jerseys, Shorthorns, North Devons, Herefords and Ayrshires, with others in less quantity.

Beef and Hides.—On the Bush Veld and over much of the Grassland beef production and hides are the objects of cattle rearing. In 1931, 9,576 tons of beef and 14,812 tons of hides, produced from South African animals, were exported. This figure is exclusive of the products of animals reared in Rhodesia or South-West Africa, which pass through the Union.

The quality of beef is not very high. This has been considered as due in part to lack of phosphorus in the soils and vegetation. This deficiency may become serious and lead to disease. Throughout the cattle regions the administration of rations of bone meal or other phosphates, in addition to the normal diet, has proved advantageous both to the general welfare of the animals and to the quality of the meat.

Dairy Produce.—Dairying is carried on principally in the Temperate Savanna, the eastern parts of the Grassland, and to a less extent in the Bush Savanna. A small amount of dairying is carried on in the Sclerophyll region of the coastal belt.

For successful dairying it is essential to have perennial fodder. In 1930, out of the total number of cattle, 1,911, 575, or approximately a fifth, were specifically dairy animals. For dairy produce imported breeds are mainly used. Mixed breeds are much the commonest, but pure-bred stock is becoming increasingly common on the more progressive farms. Frieslands, Jerseys, Ayrshires and Shorthorns, and mixtures of these, are the most favoured, but others thrive well. Improvement in breed has often been found to give an increase in the quantity of milk.

Butter and cheese are now produced in considerable quantity for export; an export subsidy is given. The cheese made is of the "Cheddar" and "Gouda" types, with the small "Kraft" cheese in less amount. The more specialised kinds of cheese are not produced. There are now sixty-three creameries, 105 cheese factories and three factories for the manufacture of condensed milk in the country.

The local manufacture of butter and cheese on the farms is gradually being replaced by these central factories, which have a system for the collection of milk from the farms.

TABLE 31.—*Dairy Produce*

	Production (tons).	Export (tons).
Butter . . .	17,641	2,539
Cheese . . .	2,606	708

Sheep and Wool.—South Africa now stands fifth in the list of the wool-producing countries of the world. Sheep rearing is the principal resource of the arid parts of the country. The Karroo Bush vegetation is especially productive, the Succulent Bush slightly less so. Other large sheep-rearing areas are the drier and the upland parts of the Grasslands. Sheep in lesser numbers are kept in the other types of arid vegetation and the Dry Sclerophyll Bush.

Indigenous sheep occur in the country and are kept in the arid parts of Bushmanland. These animals are used for meat production but are of no value for wool. Imported animals, especially merino and merino crosses, have been exceedingly successful. The following figures give the production and export :—

TABLE 32.—*Sheep Production and Export of Wool, Skins and Mutton*

	Production (tons).	Export (tons).
Wool . . .	130,715	126,205
Sheepskins . . .	—	16,832
Mutton . . .	—	7,255

Goats.—Goats are very commonly kept along with sheep in the drier regions. In addition to common goats, Angora goats are reared and an export trade in mohair has been established. Mohair production is localised in the eastern Cape Midlands, in the Karroo Bush vegetation and the adjacent drier parts of the Temperate Savanna. Of a total production of 3,133 tons, more than 2,700 were from Karroo Bush. The export was 3,070 tons. In addition, 3,022 tons of goat skins were exported.

Pigs.—Pig keeping is not specially localised and is nowhere on a very large scale. The eastern parts of the Grassland and Temperate Savanna produce most. In 1930, 3,971 tons of bacon and ham were produced and 406 tons of lard ; the exports were 207 and 2 tons respectively.

Horses and Mules.—These are bred on the Grasslands and southern

parts of the Temperate Savanna and to a small extent in the Sclerophyll. The more tropical regions are unsuitable owing to disease.

Donkeys.—Donkeys are the common transport animals for farm and other purposes, especially in the drier regions.

Ostriches.—Ostriches were formerly kept in large numbers and provided the main source of income to farmers in the Little Karroo and elsewhere. At the present time the feather industry has shrunk to small dimensions, and, though the eggs and skins have some value, the number of birds has decreased from 776,313 in 1913 to 31,818 in 1930. At the time when ostrich farming was at its height the growth of natural vegetation was not able to support the numbers of birds, which were largely fed on sown crops. The export of feathers in 1930 was 38 tons.

Poultry.—Poultry keeping is general except in the arid regions, but is largest in the southern coastal regions. There is an export of eggs which has risen rapidly in recent years.

TABLE 33.—*Export of Eggs*

Average 1910–14	1,265,257
,, 1925–29	39,899,403
,, 1930–34	60,424,619

CROPS

Cereals.—The chief cereals grown are maize, wheat, oats and Kaffir corn: barley, rye, and others are grown on a smaller scale. The production of grain varies considerably from year to year, dependent on the season. The export of cereals has decreased somewhat in recent years.

TABLE 34.—*Production and Export of Cereals*

	Production (tons).		Export (tons).		
	1924–25.	1934–35.		Average, 1925–29.	Average, 1930–34.
Maize . .	2,169,695	1,657,239		400,252	256,730
Wheat . .	246,686	453,654	(grain)	45,734	22,048
			(flour)	95,044	229,633
Oats . .	108,149	94,269		2,583	305
Barley . .	22,796	24,827		9	26
Kaffir Corn .	67,209	123,270		6,500	1,421
Rye . . .	16,859	22,944		—	—

Maize.—This is much the largest crop. It is grown all over the summer rainfall regions, but principally in the central part of the Grassland, in the northern Orange Free State and the southern Transvaal. This region produces more than half the total. The Bush Veld and Temperate Savanna come next in importance.

Even in the central growing districts the yield is rather low: the average for the whole country is 2·6 bags (of 200 lbs.) per acre; in the main maize belt it rises to nearly three bags per acre. In a few places as much as six bags are obtained, which shows what can be done. Lack of fertility in the soil and of added fertilisers are responsible for the low yields. Maize is now the staple crop of many of the natives. It is taking the place of Kaffir corn, which was their original main crop.

Wheat.—Wheat is grown mostly on the coastal plain in the region of Sclerophyll vegetation. The only other region producing wheat in any quantity is the higher part of the Grassland. Four-fifths of the total are produced in the Sclerophyll climate; in this region there are 704,966 acres under wheat. The average yield is about 12 bushels per acre. In the Sclerophyll region wheat is sown in March and harvested in October or November; no rotation of crops is employed as a rule, and land is allowed to lie fallow every fourth year.

Oats.—As a cereal crop oats are practically confined to the Sclerophyll climate, and especially to the drier parts north of Table Bay; 433,148 acres are under oats there. In other parts oats are grown largely but are cut young and used for hay.

Barley is a lesser crop grown in the Sclerophyll climate.

Kaffir Corn.—This is grown in all the native areas: elsewhere it is mostly in the Temperate Savanna, Low Veld and Bush Veld. In addition to the ordinary Kaffir corns (*Sorghum* spp.), the bulrush millet (*Pennisetum typhoideum*) and finger millet (*Eleusine coracana*) are grown in the northern Bush Veld.

OTHER CROPS

The accompanying table gives statistics of the principal items :—

TABLE 35

	Acreage.	Production (tons).	Export (tons). Average, 1925–29.	Average, 1930–34.
Sugar . .	355,714	372,605 (sugar)	69,271	151,454
		(sugar products)	19,139	19,429
Tea . .	2,139	(manufd.) 387		
		(green) 1,540	51	3
Cotton . .		(raw) 1,558	2,504	1,118
Tobacco .	30,816	7,260	369	460
	(European only)			
Potatoes .	82,930	15,114	2,044	2,936
Hay & Fodder	—	572,986	89,917	41,846

Sugar.—Sugar-growing is confined to the Sub-tropical Forest type, and especially its northern parts. The production is now sufficient to supply the needs of the country and to support an export trade.

Tea is also confined to the Sub-tropical Forest type. Coffee was at one time grown here but was ousted by disease.

Cotton.—This is not at present a very extensively grown crop. The centre of its cultivation is the Low Veld. Small amounts are grown in the Sub-tropical Forest type and also on the irrigation works at Kakamas on the Orange River. In the Low Veld cotton can be grown successfully without irrigation. The cotton grown is the strain known as U4, which was developed at the experimental station established at Barberton by the Empire Cotton Growers Association. This strain is now grown, practically to the exclusion of all others, not only in the Low Veld, but also in Rhodesia, Nyasaland, and to a large extent in Kenya, Uganda and the Sudan.

In the Low Veld cotton is grown along with maize, generally on a one year rotation. The acreage and production of cotton have undergone large fluctuations. During the " boom " years, 1924–26, cotton was widely grown. Immediately afterwards falling prices caused a rapid decrease. At present the acreage is slowly but steadily increasing. During the period of high prices cotton was grown in places outside the Low Veld vegetation but did not prove an economic crop there under ordinary conditions. In the Low Veld it is calculated that cotton can be produced economically when

the price of raw cotton does not fall below 6*d.* per pound. The following table illustrates the changes in cotton growing :—

TABLE 36.—*Production of Cotton (Unginned)*

	Total Acreage.	Total Production. (lbs.)	Production in Low Veld and Sub-trop. Forest. (lbs.)
1918–19	—	1,418,611	1,416,505
1921–22	15,169	2,806,367	2,788,817
1924–25	145,550	20,391,818	19,789,401
1927–28	30,029	12,013,970	11,464,147
1930–31	—	9,074,093	5,344,003
1932–33	about 50,000	2,123,424	1,865,320

Tobacco.—The chief areas for tobacco cultivation are on the boundaries of the Bush Veld and Grassland types and in the Sclerophyll. Turkish tobacco is confined to the latter.

The amount produced and the area under the crop have varied from time to time with changes in price and demand. The following table gives the relevant figures for recent years :—

TABLE 37.—*Production of Tobacco*

	S. Africa.	Bush Veld and Grassland.		Sclerophyll.	
	Production (tons).	Acreage.	Production (tons).	Acres.	Production (tons).
1921	6,700	15,711	3,778	8,121	2,235
1923	3,828	12,199	2,220	5,919	1,366
1926	6,877	15,035	3,538	9,000	2,840
1928	9,830	29,305	6,902	8,671	2,253
1930	5,477	11,992	2,756	8,279	2,311
1932	9,419	—	6,428	—	2,500
1935	7,260	23,107	5,056	—	206

At the present time the tobacco grown is almost all manufactured and consumed locally. The export is a small fraction of the total and one that does not show any immediate tendency to rise. Until a larger export market can be obtained the cultivation will not increase much beyond its present level. The table gives the amount and value of the tobacco export from the Union as a whole :—

TABLE 38.—*Tobacco Exports*

	Amount (tons).	Value (£).
Average 1910–14 . . .	78·5	12,425
,, 1920–24 . . .	603	53,968
,, 1925–29 . . .	369	65,804
1930	374	53,627
1931	94	21,479
1932	34	8,580
1934	74	29,677

Potatoes are grown in largest quantities in the Grassland. Lesser quantities are grown on the coast belt in the Sclerophyll and Temperate Savanna types.

Hay Crops include lucerne (*Medicago sativa*), teff-grass (*Eragrostis abyssinica*), oats, and "Boer manna" (*Setaria italica*).

FRUIT

Fruit-growing is one of the important industries of the country: 289,647 acres are devoted to fruit trees and 75,000 acres to vineyards. The accompanying table gives statistics for the chief productions:—

TABLE 39.—*Production and Export of Fruit*

A. FRESH FRUIT

	No. of Trees.	Export. Amount (Shipping tons = 40 cubic feet).	Export. Value (£).
Citrus:			
Oranges . .	3,883,350	118,014	1,096,621
Grape Fruit .		16,016	149,059
Tangerine . .	272,260	386	3,707
Lemon . .	196,890	2,062	12,072
Pineapple . .		2,170	14,616
Deciduous Fruit Trees:			
Pear . . .	1,009,740	21,528	237,932
Peach. . .	3,590,670	3,878	106,458
Plum . . .	1,379,250	8,044	133,578
Apple. . .	2,464,370	4,262	70,149
Nectarine . .	76,420	434	17,310
Apricot . .	2,190,820	784	10,775
Grapes . .	102,107,984	29,641	420,108
Other Fruit . .	202,341	330	7,071

B. Dried Fruit and Fruit Products

	Production.	Export. Amount.	Export. Value (£).
Wine	15,899,150 gal.	1,401,775 gal.	190,483
Brandy	2,677,961 ,,	58,736 ,,	8,645
Raisins	4,295 tons	4,147 tons	154,663
Dried Fruit (other)	4,687 ,,	1,500 ,,	158,682
Jam	10,002 ,,	4,950 ,,	
Canned & Bottled Fruit	5,727 ,,	1,363 ,,	

Citrus.—The chief centres of citrus-growing are in the Low Veld and the Temperate Savanna types. Citrus is also grown in the Bush Veld and in the Sclerophyll region with irrigation.

Pineapples.—These are grown in the lower parts of the Temperate Savanna and the Sub-tropical Forest types.

Deciduous Fruit Trees.—The Sclerophyll is much the most important area for growing deciduous fruit trees. The amounts grown in other types of vegetation are quite small.

Grapes.—Vine cultivation is almost entirely restricted to the Sclerophyll vegetation and to that part of the coast belt near the base of the mountains. Of the total of 75,000 acres of vineyards, 72,605 are in this portion. The vine was the first fruit to be imported for growth.

Other Fruit.—The table gives the amounts and chief types for the growth of the more important of the other fruits :—

Table 40.—*Export of Other Fruits*

	Export. Amount (shipping tons).	Export. Value (£).	Vegetation where Grown.
Bananas	—	1,599	Sub-trop. For. and Low Veld
Avocadoes	5	—	,, ,, ,,
Pawpaws	1	13	,, ,, ,,
Mangoes	14	227	,, ,, ,,
Melons.	181	1,980	General, with Irrigation
Figs	2		Sclerophyll
Cape Gooseberry	1		Sclerophyll and Temp. Sav.
Quinces	2		Sclerophyll
Tomatoes	10		Low Veld, and with Irrigation
Litchis.	101		Sub-trop. For. and Low Veld

The canned and dried fruit industry and jam making are centred in the Sclerophyll vegetation.

NATURAL RESOURCES

South African vegetation has yielded very few plants or plant products of value other than timber. Such as occur have been mentioned under the various types in which they are found.

Timber.—A large part of the country is quite treeless, and most of the large Savanna areas are of little value for timber production. The production of timber is far below the demand and there is a complete lack of soft-wood. Importation of timber is needed to supply the demand.

The introduction of exotic trees is going on but the supplies are still far below what is needed. In 1930 the total production in the country, from both forests and plantations, was 14,767,527 cubic feet, while the importation was 17,338,180 cubic feet. The home-produced timber was also largely of small size, only suitable for firewood. The actual figures were :—

TABLE 41.—*Production of Timber*

Sawn Timber	653,010 cu. ft.
Small Timber (mine props, fencing posts, etc.)	2,559,777 ,,
Firewood	11,554,740 ,,

Importation of Timber

Pine	10,894,536 cu. ft.
Teak	542,484 ,,
Oak	650,774 ,,
Jarrah and Karri	213,143 ,,
Other Timber	1,758,755 ,,
Floor and Ceiling Boards	3,278,961 ,,

The exotic trees that have been most planted are pines, eucalypts and wattles. The last are not really timber trees. Plantations now cover an area of over 990,000 acres, made up as follows :—

TABLE 42.—*Area of Plantations*

	Total Acres.	Govt. owned.
Wattles	531,025	12,972
Eucalypts	214,047	39,079
Conifers	178,754	126,230
Poplars	19,681	1,007
Other Trees	46,568	14,281

The Government, through the Department of Forestry, now owns most of the indigenous forests and the exploitation of them is under control. Notes on afforestation and on the wattle industry have been included under the vegetation types.

MINERALS AND MINING

Mining is undoubtedly the most important economic activity in the Union, and on the mineral resources its continued prosperity depends. This is brought out very clearly in the figures for the values of the exports, which in 1934 were :—

Products of Mines. . . .	£61,489,856
Agricultural Products . . .	£16,162,269
All other Products . . .	£517,220

Nearly 20 per cent. of the State revenue is obtained directly from the mines. This figure does not take account of the indirect sources of revenue which are associated with mining. The actual figures were £5,260,506 directly from the mines out of a total of £28,441,852. Of the metals mined gold is much the most valuable. For a long time diamonds took the second place. Even during the period of world depression, though the output and value decreased very quickly, diamonds were only surpassed in export value by gold and coal. Copper and other minerals are of lesser importance when compared with these.

The table gives figures for the production and export of the principal minerals :—

TABLE 43.—*Production and Export of Minerals*

A. PRODUCTION

	Amount.		Value (£).	
	1930.	1935.	1930.	1935.
	Fine Oz.			
Gold . .	10,716,251	10,773,991	45,520,166	45,765,065
Silver . .	1,031,779	1,042,203	83,414	135,903
Osmiridium .	5,721	5,279	69,267	24,460
Platinum .	47,021	31,338	327,884	179,697
	Metric Carats.			
Diamonds .	3,163,590	676,722	8,340,719	2,171,267

	Amount.		Value (£).	
	1930.	1935.	1930.	1935.
	Tons.			
Asbestos .	17,215	20,358	340,795	226,881
Chrome Ore .	22,532	96,036	44,129	174,859
Coal . .	11,702,065	13,042,503	3,494,350	3,359,796
Copper. .	8,708	10,649	520,048	323,674
Corundum .	1,125	4,263	17,635	36,552
Iron . .	50,892	299,247	19,899	144,988
Manganese .	53,144	88,579	91,858	126,239
Soda . .	2,312	1,855	29,414	26,406
Salt . .	87,927	81,918	136,977	83,911
Tin . .	1,139	930	118,200	136,359

B. Export

	Average, 1925–29.		Average, 1930–34.	
	Amount.	Value.	Amount.	Value.
	Fine Oz.	£	Fine Oz.	£
Gold . .	7,217,596	30,658,340	9,531,323	49,121,579
Silver . .	979,585	122,573	763,219	53,379
Osmiridium .	4,551	97,326	5,706	47,266
Platinum .	—	135,948	—	174,690
	Metric Carats.		Metric Carats.	
Diamonds .	3,252,101	10,517,116	1,185,293	3,191,155
	Tons.		Tons.	
Asbestos .	9,195	159,042	12,888	233,792
Chrome .	20,840	36,776	27,064	61,033
Coal . .	3,311,290	3,116,146	1,819,004	1,443,060
Copper. .	326	13,047	1,138	8,379
Corundum .	2,537	25,943	1,341	13,636
Iron . .	—	—	—	—
Manganese .	—	—	—	—
Tin . .	1,886	286,740	892	113,773

Minerals of mining value are found for the most part in the ancient rocks forming the northern margin of the great Karroo System and especially in the Transvaal. Some are associated with the great igneous intrusions of the Bush Veld area.

Gold.—Gold was known in the territories north of the Union in ancient times and within the boundaries traces of ancient gold workings have been found in the mountains near Pietersburg, in the northern Transvaal. For practical purposes, however, the discovery of gold within the Union was not made till the second half of the nineteenth century. The first discovery was in alluvial

deposits in the eastern Transvaal. The discovery of the Witwatersrand gold was made in 1884, when gold-bearing quartz veins were found. In 1885 the gold-bearing conglomerate or " banket " was found, and this has since proved very much the most valuable source of the metal. This conglomerate forms bands running through the rocks of the Upper Witwatersrand series, which, in the Transvaal, form a ridge with an elevation reaching over 6,000 feet (1,830 m.). The rocks are extensively faulted, and in following the gold-bearing conglomerate some of the mines have reached very great depths, the greatest being about 7,500 feet (2,286 m.) from the surface. The Witwatersrand is much the largest gold-mining area, though there are others from which the metal is produced. The figures for 1933 are :—

Witwatersrand . . .	10,405,184	fine oz.
All other Transvaal Mines .	607,156	,,
Rest of South Africa . .	1,372	,,

The methods used for the extraction of gold vary to some extent in the different mines. The gold-bearing rock is crushed and a first separation carried out by gravity. The crushed material is passed over strips of corduroy cloth to which the heavier metals stick. The gold is obtained from the cloth by amalgamation with mercury. The remaining portion of the material is treated by the cyanide process. The residual crushed rock material is dumped in large heaps around the mines. These white dumps are conspicuous features of the landscape on the Rand. The dumps remain quite bare for long periods, but eventually the finely crushed rock is very slowly colonised by plants. The Transvaal gold mines in 1933 employed 270,347 persons, of whom about 10 per cent. were Europeans. Further they have resulted in a quite considerable industrial development in the area. The gold produced in South Africa amounts to about half of the total production of the world. Between 1927 and 1932 the Union percentage of the world's total production varied between 48·2 and 53·4.

Silver.—No workable silver deposits are present in the country, but the metal is obtained in the refining of gold.

Copper.—Copper occurs in several parts of the country and has been worked to a varying extent. At the present time the only part where production is active is near Messina, on the northern

flank of the Zoutpansberg. The mines here have suffered from difficulties arising from the unhealthy climate, but anti-malarial measures have recently enabled work to be carried on without trouble. The earliest discovery of copper in the country was made in 1685 in Namaqualand. Work was commenced there in 1852 and, in spite of difficulties of transport and lack of water, the output in 1915 was 13,973 tons. Since then the output has declined and the workings are now closed. Copper was worked along with gold in the Lydenburg district, but activities closed down in 1931. Copper in workable quantities occurs in the north-west of the Cape Province, in the districts of Prieska and Gordonia. Copper pyrites occurs in workable quantity at Mount Ayliff in East Griqualand.

Tin.—Tin is found in lodes in granite and other rocks. The most important source is the Bush Veld igneous complex, where it occurs at or near the contacts. Tin also occurs at other igneous contacts, and was at one time worked at Kuils River near Cape Town. Alluvial tin occurs in the Low Veld region in the Transvaal and Swaziland. There is evidence that tin was worked in ancient times in the Transvaal.

Platinum and Allied Metals.—These are found in various igneous rocks and also in the black sand obtained on concentration of the crushed rock in the process of gold extraction. Osmiridium is one of the most important substances thus obtained. Platinum is worked in the Bush Veld igneous rocks and near Lydenburg. The actual production, and still more the export, of the metal has fluctuated considerably with variations in price. The following table illustrates this :—

TABLE 44.—*Production and Export of Platinum*

	Production.	Sales.	Export.
1927 .	19,070 fine oz.	10,431 fine oz.	
1928 .	23,662 ,,	17,826 ,,	
1929 .	29,813 ,,	21,607 ,,	
1930 .	55,342 ,,	47,021 ,,	41,132 lb. concentrates
1931 .	47,162 ,,	36,545 ,,	36,021 ,, ,,
1932 .	9,246 ,,	7,086 ,,	7,800 ,, ,,
1934 .	37,741 ,,	22,899 ,,	22,014 ,, ,,
1935 .	31,271 ,,	31,337 ,,	

N.B.—The platinum concentrate has about 5·82 oz. platinum per ton.

Antimony occurs in the Zoutpansberg and also in the Murchison Range in the Transvaal, where it is associated with the gold mines. It was worked successfully during the war period but not since.

Iron.—Large quantities of iron ore occur in various places and traces of ancient iron workings are found in the north-east of the country. Of modern workings, those near Newcastle, in Natal, were the most important until quite recently, when the works were closed. Other iron works are at Vereeniging, on the Vaal River, and quite newly established ones at Pretoria, with mines there and near Rustenburg. The iron resources of the country have so far been little exploited and large quantities are imported annually.

Chrome Ore.—Considerable quantities of chrome ore occur in some of the rocks of the Bush Veld igneous complex, and these ores are also worked at Rustenburg and at Lydenburg. Though the Transvaal ore is less rich than that from some other countries, it is easily mined, labour is cheap, and transport not too severe, so that an export trade has been established.

Manganese.—Manganese is worked principally at Postmasburg in Griqualand West. Small manganese mines have been opened in various parts of the south-western Cape Province, but none of them has paid.

Diamonds.—From the standpoint of value diamonds, until a few years ago, were among the most important products of the country. Even with the depression during the years 1931-33, though the value steadily declined, the diamond trade was only surpassed by gold and coal. Diamonds were first found in alluvial deposits along the Vaal River in 1867. In 1870 the famous diamondiferous volcanic pipes at Kimberley were found, and for some time mining in them produced the main supply. These ancient volcanic pipes, which have yielded diamonds, occur in various parts of the plateau. The most important are near Kimberley. The largest individual pipe is near Pretoria, where the Premier Mine has the distinction of having yielded the largest stone found in the country. Other diamond-yielding pipes occur in the western part of the Orange Free State at Jaggersfontein, Koffyfontein, Kroonstad and elsewhere. The diamonds are found in the material plugging the vent, which is known as Kimberlite, or "blue ground."

At first the diamonds were obtained from surface workings and some mines have always been so worked, but in the richer ones

shafts have been sunk and tunnels made. Some of the mines penetrate to depths of 2,000 feet (610 m.) from the surface. The Kimberley Mine, which has not been worked since 1914, has been proved to have diamond-yielding blue ground to a depth of more than 3,600 feet (1,100 m.) from the surface.

In 1908 large alluvial deposits containing diamonds were discovered in South-West Africa, and in 1920 similar deposits were found in the south-western Transvaal, in the valleys of the Rivers Vaal and Hartz. In 1927 immense quantities of alluvial diamonds were discovered on the coast of Namaqualand, near the mouth of the Orange River. These discoveries, coming practically simultaneously with the world depression, seriously affected the diamond mines, most of which ceased working for the time, but are now reviving. The danger of flooding the market with stones induced the Government of the Union to take control of the coastal alluvial diggings and to place considerable restrictions on the output. Up till 1928 South Africa produced more than half the diamonds of the world, but since then the proportion has been less. Since 1931 the stoppage of the mines has seriously reduced the country's output. Table 45 gives the figures for the diamond output and value for the twelve years 1924–35 :—

TABLE 45.—*Diamond Output and Value*

	Output Metric Carats.	Value £
1924 . . .	2,440,398	8,033,406
1925 . . .	2,430,129	8,198,128
1926 . . .	3,217,966	10,683,597
1927 . . .	4,708,038	12,392,308
1928 . . .	4,372,857	16,677,772
1929 . . .	3,661,212	10,590,113
1930 . . .	3,163,591	8,340,719
1931 . . .	2,119,156	4,182,523
1932 . . .	798,382	1,679,600
1933 . . .	506,563	1,560,404
1934 . . .	440,313	1,437,591
1935 . . .	676,722	2,171,267

Coal.—Extensive coal seams of Karroo age occur in the country. The most important are near the northern and eastern margins of the great area of Karroo rocks. Only a small amount of the actual

coal in the country has been exploited. The principal mining areas are in the south-east Transvaal at Witbank, Boksburg, Ermelo and Carolina, in Natal at Dundee, Vryheid, Newcastle and Klip River, and in the Orange Free State near Vereeniging and Vierfontein. Large coal deposits at present practically unworked occur near Bethal and in the vicinity of Piet Retief, and coal of uncertain extent is known of in the outliers of Karroo Rocks in the Bush Veld area on the Springbok Flats, Waterberg, Zoutspanberg, and also near Komatipoort. The coal seams of the Stormberg, in the eastern Cape Province, though the first discovered and still worked, are of low quality. The coal output is greatest in the Transvaal, though the best quality coal is got from the Natal fields. Natal coal is especially good for furnace work and coke production. Anthracite seams occur here. The actual figures for the fields were in 1933 :—

Transvaal . . .	6,229,684 tons.
Natal	2,782,596 ,,
Orange Free State . .	1,276,096 ,,
Cape	4,445 ,,

Of the coal output about half is consumed by the mines and railways. Of the coal exported more than half is in the form of bunker coal for steamships.

Asbestos.—More than one kind of asbestos is worked in the country. The more important varieties are (1) *Chrysolite* or White Asbestos, which is found in the rocks in the eastern Transvaal and Swaziland and worked principally in the districts of Barberton and Carolina ; (2) *Crocidolite* or Blue Asbestos, found chiefly in the Asbestos Mountains in Griqualand West and also in the Pietersburg and Lydenburg districts in the Transvaal ; (3) *Anosite*, sometimes termed Yellow Asbestos, found in the rocks of the Bush Veld igneous complex.

Large quantities of asbestos of short fibre occur in the country but do not pay to work. The production of asbestos has fluctuated greatly with variations of price and other factors. The amounts of the different varieties produced in 1932 were :—

Chrysolite	6,887 tons.
Crocidolite	2,646 ,,
Anosite	1,241 ,,

Salt.—While no deposits of rock salt occur in the Union, salt is obtained from pans in the more arid regions in the south-western Transvaal, near Pretoria, and in Griqualand West, in sufficient quantity to supply the needs of the country.

Cement and Lime.—The available limestones are worked in several places for lime and "Portland Cement." Cement works have been established at Pretoria, Piquetberg and elsewhere.

Building Stone.—The country generally is well supplied with building stone, though no very extensive quarries occur. Constructional work is most commonly of bricks, which are made from clays in many places. In 1930, 337 million building bricks were made and 7½ million roofing tiles. In the country districts sun-dried bricks are often used.

Other mineral substances which are worked, but only on a small scale, are corundum, gypsum and steatite.

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See also Nos. (2), (4), (6), (7) of References in Chap. I; (5) (Chap. II); (6) (Chap. VII); (2), (3) (Chap. VIII).

CHAPTER XI

GENERAL CONCLUSIONS AND PROSPECTS

BIO-GEOGRAPHICAL REGIONS

THE various types of vegetation occurring in the Union of South Africa can be grouped into larger units of a biological-climatic-geographic kind. These larger units do not correspond exactly with the classes into which the types fall; neither forest nor savanna, for example, really form units from this point of view.

It has been pointed out already that some of the types are closely related to and represent southward extensions of vegetation more fully developed in more tropical regions to the north. The Low Veld and Bush Veld are clear examples of this, while the Temperate Savanna is a still more southern extension. Exactly the same applies to the Montane Forest and to the Sub-tropical Forest, though the last is an extension from the low ground near the coast, not from the interior. These can all be grouped together as a unit of East Central African affinity and termed the *East Central African* group. To this also belongs the Warm Temperate Forest and Grassland. The last is closely allied to the group and is the reaction to a colder and more continental type of climate.

The Bush Savanna, as has been noted, is placed in another group, on account of its distinctive flora and structure, the affinities of which are also tropical but with the regions further west. It belongs to the group that can be termed the *Kalahari* group. No other South African type falls in this division.

The Sclerophyll type is exceedingly distinct, separated from both of the above in vegetation structure, and especially in flora. It is part of a third group that can be termed the *Southern African*. To this group the Temperate Forest may be united. This kind of forest has undoubted affinities with the Warm Temperate and Montane Forests which are placed in the East Central African group. Indeed, the flora of Temperate Forest is often regarded as the extreme southern extension of the tropical African flora, but against this

must be put the extremely close geographical and developmental similarities with the Sclerophyll type. These are so great that they seem to outweigh the floristic relations, which may be explicable on the ground of the general poverty in forest plants of southern Africa as a whole.

The relations of the Semi-Desert vegetation are less obvious. In the case of these types of arid regions floristic characters are the only guides to relationships, as the structure is completely dominated by the severe conditions. The Karroo Bush type is more akin in flora to the types of the East Central African group, whereas the Succulent Bush has many features in common with the Southern African.

The *Rhigozum* and Desert communities have a very distinctive flora which is sharply contrasted with that of other parts of the arid regions. It has greatest similarities with the flora of South-West Africa, and, though showing some relations to the Kalahari group, is probably best regarded as representing a fourth division, the *Namib* group.

To summarise, the vegetation can be divided into four groups :—

(*a*) East Central African, occupying the whole of the eastern portion and including Low Veld, Bush Veld, Temperate Savanna, Grassland, Montane, Warm Temperate and Sub-tropical Forest and Karroo Bush.

(*b*) Kalahari in the north-central part and represented by the Bush Savanna.

(*c*) Southern African in the south-western parts, comprising Sclerophyll, Succulent Bush, and probably Temperate Forest.

(*d*) Namib in the north-west, represented by the *Rhigozum* and Desert communities.

COMPARISONS WITH OTHER REGIONS

In the correlation of vegetation with climate, and in the grouping of the types into larger units, comparisons with other regions and with the distribution in other lands provide a valuable guide to and check on the conclusions.

For comparison with South Africa, the other land masses in the Southern Hemisphere are the most satisfactory, and of these especi-

ally Australia and South America. New Zealand, though more completely investigated ecologically than any other southern region, has such pronounced differences in climate that it is less comparable.

The distinctive features of topography and climate in South Africa produce conditions affecting vegetation which are not at all closely paralleled in either of the other southern continents. In place of the South African high tableland the central portions of Australia take the form of a low saucer, and this results in different distributions of climate not only in the interior itself but also in the coastal belt. The extensive high tableland is also wanting in South America. Comparisons with any part of the Northern Hemisphere are bound to be less exact owing to the great differences in the distribution of land masses and consequently of climate. But, allowing for these differences due to the physical features of the country, comparisons of value can be made with generally corresponding climatic regions in the other countries. In these comparisons those with Australia will usually be put first, as that continent is the part of the Empire with the greatest similarity in latitude and climate.

Of the four groups of vegetation types in the country the East Central African, which is tropical in character, has its counterpart in many other regions. The extensive Savanna types are characteristic of the drier parts of the tropics generally. Vegetation closely similar in structure and development covers considerable areas in the more tropical parts of Australia and also in South America. These Savanna types have been variously looked upon as related either to forest or to grassland. Most often they appear as characteristic of conditions intermediate between the two and are developed in warm continental climates with a seasonal rainfall. The South African Grassland or High Veld presents many peculiar features. While in flora it is associated with tropical vegetation, yet owing to its altitude the High Veld exists in a temperate climate and presents some of the features of structure more characteristic of temperate grasslands such as the South Russian steppes and the American prairie.

The Montane Grasslands really belong to a quite distinct type, and might be placed in a separate group. They are a moist temperate type which occurs on the high mountains through Central Africa, and has close parallels with mountain grasslands in other regions.

This Montane Grassland is the only vegetation that can be looked upon as correlated with mountain conditions. There is in South Africa no parallel to the Alpine or sub-Alpine vegetation of other mountain regions. The Kalahari group, which occupies a rather small area within the Union, is similar in many features to the arid bush vegetation which is so extensive in Australia. The characteristic type of climate, warm and continental with low rainfall, is much more common in Australia, where very many vegetation types that would fall into this general group are found. The "Mallee" type of Australia, that occurs in climates intermediate between those of the Arid Bush vegetation and Savanna types, has no strict counterpart in South Africa.

The group termed South African, which includes the Sclerophyll and Temperate Forests, presents features both of similarity and contrast with other regions of corresponding climate. The Sclerophyll has long been recognised as essentially similar to the vegetation of other winter rainfall regions in the warm temperate zone, such as south-western and southern Australia, central Chile, the western Mediterranean and southern California. The vegetation in all these regions agrees in the main essentials. In this country the most distinctive features are the absence of tree growth and prevalence of very small heath-like leaves. The Sclerophyll Forest, which forms the normal climax in other regions, is here scarcely represented. The nearest approach is in the very local groves of silver trees (*Leucadendron argenteum*). The bush climax of the Cape is more like pre-climax phases in the other regions. The absence of trees here seems rather a chance result of evolution of the flora than a distinctive reaction to climate. The trees of other Sclerophyll regions flourish when they are introduced; *Pinus pinaster*, *P. radiata*, etc., and *Eucalyptus* spp., are examples.

The Temperate Forest is wholly unlike the Sclerophyll Forests of other regions. It is a reaction to a different and moister type of climate. The forests in this country find their closest parallel in the "Laurel" forests of Teneriffe and other Atlantic Islands. Comparisons can be drawn with the *Nothofagus* forests in Chile and the *Sequoia* forests in California. In both the relationship to the surrounding Sclerophyll vegetation is similar, but the forests differ in their simpler structure, which is associated with the dominance of a single species. The Temperate Forests have been compared with

the Temperate Rain Forests of south-eastern Australia, Tasmania and New Zealand, but the similarities do not extend to any details. The Montane Forest comes nearer these than the Temperate.

The possible comparisons between the Montane types of Sclerophyll and the upland vegetation of Tasmania and New Zealand has been mentioned earlier.

The Semi-Desert vegetation of South Africa exhibits the general characteristics of such vegetation in other regions. The prevalence of succulent plants and complete absence of larger bushes are points of difference as compared with the arid parts of Australia. The "Salt Bush" is the Australian type that shows the closest similarity to the succulent types, but it differs in the general structure and physiognomy of the plants. Karroo Bush has a general external similarity to certain kinds of Salt Bush both in colour and size, but the leaf characters are wholly different. Closer parallels can be made with the drier parts of the American continent, and especially between the less extreme forms, such as the Tall Succulent Bush and Coastal Succulent Bush and some of the Semi-Desert communities there. The similarities to the vegetation of Arizona, for example, have been noted by several visitors. The more extreme Desert types are structurally similar wherever such conditions are found.

While in general terms all the vegetation types in the country have greater or less agreement in character with those in corresponding types of climate elsewhere, the association of the types together as they are found in South Africa is distinctive and due to the physical and climatic features of the country.

NATURAL AND POLITICAL BOUNDARIES

A glance at the map showing the distribution of the vegetation types will show that the boundaries of these have no strict correlation with political boundaries. This applies both to the boundaries of the Union as a whole and to those of the provinces which, previous to 1910, represented separate states or colonies. In many cases the boundaries cut right across regions of natural vegetation and only occasionally correspond to natural divisions. The absence of correspondence between the political and natural boundaries is in part the result of the utilisation of rivers for the former. The valley cut out by a river may form a natural boundary, but the river itself very rarely does so. The lack of coincidence of boun-

daries is partly the result of the history of the divisions. The interior regions were settled gradually with outward spreading from the first centres. The final boundaries made were generally arbitrary and drawn for convenience. For example, both in the Transvaal and in the Orange Free State, settlement commenced in the better watered parts and extended westward, where a quite arbitrary boundary was ultimately drawn. The discovery of diamonds at Kimberley was one factor which influenced the fixation of the boundaries, but it was a factor without relation to vegetation. When the boundaries of the larger political divisions bear so little relation to the natural boundaries of the vegetation types, it is not surprising to find that the smaller administrative units have boundaries that seem to coincide with the natural ones by chance only.

CHANGES OF CLIMATE

The natural divisions of the vegetation are the result of the distribution of the different factors of the climate, and their stability or otherwise is dependent on the degree of fixity of the climatic distribution. In a country such as South Africa, of which so large a part has an arid or semi-arid type of climate, the fixity or alteration of the climate becomes a matter of considerable practical importance. Any change towards increasing or decreasing aridity would bring into being necessary changes in the utilisation and development of the land. There is about the country, and more especially in the drier regions, a prevalent opinion among farmers and others that the climate is becoming less favourable, *i.e.*, more arid. The view seems to be based on observations that vegetation is becoming poorer and that rivers, streams and springs have a more intermittent or lesser flow than occurred formerly.

Direct observations in the country do not extend over a period sufficiently long to provide data which could either support or disprove this view. The longest continuous series of observations are those taken in Cape Town, which extend back for ninety-five years, but over most of the country the period during which records have been kept is very much less. As a result indirect sources of evidence have to be made use of to get the answer to the question.

Evidence obtained from geology shows that in the remote past the country has undergone some very decided changes of climate.

Desert conditions prevailed during the deposition of the Table Mountain Sandstone, and this was followed by a more favourable climate in the succeeding periods. At the commencement of the Karroo Epoch the climate underwent a striking change with the appearance of glacial conditions. Subsequently, for the prolonged period represented by the time of deposition of the vast series of strata from the Upper Dwyka to the Stormberg Series, a climate favourable to vegetation prevailed. Near the close of the Karroo Epoch arid conditions again occurred. The thick Cave Sandstone which forms the top of the Stormberg Series seems to have formed here under very dry conditions. This dry period, combined with the intense volcanic activity that followed it, appears to have brought about the extinction of the flora that had persisted with only gradual change for so long a time.

While these early examples are important in demonstrating the existence of large climatic changes, they have no influence on the present distribution and characters of climate and vegetation. In South Africa Tertiary sediments containing fossils are limited in extent, and those that have been investigated have not yielded results which help in the characterisation of the climate. The plant fossils are of a type quite compatible with existing conditions.

By far the most important and extensive deposit of Tertiary Age in the country is the Kalahari Sand, which is largely unconsolidated. This sand has all the characters of a desert deposit, and it would seem that at the time of its formation conditions approximating to those now found in the Sahara prevailed. Such arid conditions seem to have extended over a wider area than is now occupied by the Kalahari: outliers of the sand occur on the Springbok Flats and in the Waterberg District in the Transvaal, and east of the main watershed in Southern Rhodesia. Evidence for the former greater extension of these desert conditions can also be got from other sources: on the high ground of the eastern Transvaal, where the present rainfall is 30–40 inches (76–100 cm.), there are shallow pans of exactly the same kind as occur in arid regions, the origin of which is very difficult to explain except by assuming the existence of arid conditions. Again, in various parts of the Bush Veld area are hills of the "Inselberg" type. Even more striking is the discovery that in the same region oxidation has taken place in mineral veins to a depth greater than that of the present water table. As a demonstra-

tion of the former extent of these arid conditions, it may be noted that deposits of desert origin have been found as far north as 'Nchanga in Northern Rhodesia.

Over the whole of this wide region the present climate is not unfavourable : no part is now a desert. Even the heart of the so-called " Kalahari Desert " has a good covering of vegetation, and is only a " desert " in the sense that there is no available surface water. While there is this evidence for a decided amelioration of climate in the northern parts of the country, the parts at present characterised by an arid climate show some features pointing to the opposite change. In the lower reaches of the Orange River some of the tributary streams, which now carry water only after exceptionally heavy rains, have channels cut in a way that can only be explained by a much larger erosive power than they now possess.

The time at which these changes took place is not very readily determined. South Africa is without traces of the Glacial Period which marks the close of the Tertiary Age in many other countries. Also there is no example of a continuous series of recent deposits that has yielded characters by which dating could be made. The Kalahari Desert Period, to judge by the amount of erosion that has taken place, and the great reduction in the area of sand, must have been a long time ago : it is generally referred to the latter part of the Tertiary Epoch, and the changes in the present Karroo area may be about contemporaneous. Neither the existing vegetation nor flora shows any sign of the old conditions. The Kalahari flora is without characteristic desert plants, and the Karroo flora without moisture-demanding ones that might be regarded as relicts. Both floras give the appearance of stability in relation to present conditions. The changes in these regions have been associated in the suggestion that they are the result of a shift southwards in the position of the sub-tropical high-pressure belt. This shift southwards may possibly be correlated with the Pleistocene Glacial Period, when glaciers on the high mountains of Central Africa certainly descended to lower levels.

The more recent climatic history has to be built up from the investigation of river terraces, cave deposits and so forth. Some of these contain sub-recent fossils, either animal or human. The correlation of these deposits, which are found as separated examples, with those studied in east Central Africa or in northern countries, has

been attempted, but cannot yet be said to rest on a very substantial basis. Climatic fluctuations at present do not seem to be closely related in South and in tropical Africa.

The extent of climatic change during the human period in this country is still an open question. Alternations of wet and dry periods corresponding to those demonstrated in the tropics or to the alternations of glacial and inter-glacial periods of Europe have been suggested but are not conclusive. One important source of evidence for them is found in the river terraces on the Vaal: there are three of these; the oldest is 200 feet above the present river level, the second 60 feet above, and the third now forming at river level. From fossil evidence the 200-foot terrace dates from the close of the Tertiary Period. The suggestion is made that pluvial periods occurred during the time taken between the formation of successive terraces, which represent dry periods. On the other hand, the phenomena can be explained without recourse to climatic change by uplift of the continent. Elevation of the land has certainly taken place in late Tertiary and post-Tertiary times.

Generally speaking, there does not seem to be evidence for recent or contemporaneous climatic change. Those changes that have occurred are so ancient that the flora has reached a state of equilibrium.

CHANGES IN VEGETATION

Vegetation provides the most exact indicator of the *total* environmental conditions, and any changes in these are reflected in alterations in it. In accounts of the past conditions and climate of the country, vegetation such as forest, which is certainly disappearing, is often quoted as support for the view that the climate is becoming drier. There is not the least doubt that over a large part of the country the vegetation has been altered in the direction of simplification. The communities that are established are such as make less demand for water in the habitat. Some of the changes have already been described and the fact that they are due to interference demonstrated. The chief agents of the changes are overgrazing, burning and the cutting out of woody plants. So widespread has become alteration of this kind that much of the vegetation gives an impression of a less favourable climate than actually exists. Examples are to be seen in the secondary grasslands in the Savanna

types, and the Karroo-like vegetation replacing Grassland. The effects of such alterations may become as important as those provided by an actual change of climate. The simplified cover has less hold on the soil and permits increase in run-off of water and in drying out during dry periods. This may soon lead to a lessening in the reliability of springs and streams. It is possible, though scarcely yet proven, that the diminished vegetation cover increases the tendency of rainfall to come in short severe storms. All these effects are intensified by the lowering of the soil water table that will follow the sinking of numerous wells. In the more arid regions the precipitation affects the deeper soil layers very slowly, and removal of the water from these layers produces a loss that is not readily made up. There is very little reason to doubt that destruction of, and interference with, natural vegetation is producing conditions of increasing aridity over large portions of the country.

Changes of vegetation that are due to natural causes, that is to change of climate, are much more difficult to demonstrate. The rate of change will in most cases be exceedingly slow, and until continued observations of a kind which have not yet been undertaken in this country are carried out such changes might be quite easily overlooked. It is at the transition zones between different types that they might be expected to be most easily seen. In such zones, however, interference, whether human or other, produces the most rapid and most pronounced effects. Vegetation that exists near the limits of its possible conditions is more easily upset and replaced by one making less demands than is the case where the environment is more favourable. Up to the present no case has been described that would demonstrate satisfactorily any advance or retreat of a vegetation type under purely natural influences. On the other hand, such changes are certainly taking place under conditions rendered less favourable owing to interference. The induced conditions may seriously affect the possibilities of regeneration of the original climax. In other words, what may be termed secondary changes of the conditions, which, when of long duration, can bring about effects just like those of change of climate, are being induced.

Outliers of a vegetation type that are found beyond the general area of its distribution have been looked to for providing evidence of an advance or retreat of the type, but no direct evidence is available from which conclusions could be drawn.

On the other hand, the study of the distribution of species or groups of species has led to the postulation of climatic change as the only satisfactory explanation. The body of facts accumulated in this direction appears to point to a once much greater extension of moist conditions, but the date and real extent of this are matters of speculation.

As a general summary, there appears to be very little direct evidence that any extensive changes of climate have occurred within recent times. Indirect evidence certainly seems to point to a drying of the present climate, but the conclusion is not fully established. On the other hand, secondary changes in vegetation are rendering the water supplies less available and are tending towards increased aridity. In other words, the view commonly held is correct, though the cause lies more in the careless attitude taken to vegetation than in naturally occurring changes.

PROSPECTS

The rather extensive alterations that have occurred in the natural vegetation will, if allowed to continue unchecked, certainly react unfavourably on values of land for agricultural or other purposes. Destruction of vegetation has both direct and indirect effects. The former are seen in lowered value for pasturage, lack of firewood and so on. The latter are more varied and often more insidious: evils such as soil erosion may render land quite useless. Another example is the decrease in the reliability of springs. The effects of variable rainfall are much greater in altered than in untouched vegetation. A prolonged period during which the efficiency of the rainfall is lowered reacts on vegetation just like an actual decrease in precipitation: a simpler and more arid type is established. In a country where so large a part has a low total rainfall and high evaporation, any lessening in water availability becomes serious and any continued destruction of vegetation has this result.

While effects of this are most apparent in the drier parts, they are by no means confined to them. The mountain regions show a definite loss in water conservation due to destruction of vegetation. The water-holding capacity of the soil is reduced, run off greatly increased and soil erosion favoured. In addition, fully-developed vegetation is able to intercept water from mists, whereas short or

incomplete plant covers do this very little or not at all. The result of destruction of vegetation on the mountains is a reduced water supply, both in total amount and still more in the time of supply to the lower levels. The maintenance of complete vegetation on the mountains is a matter of very real importance for the future of the country.

Agriculture.—South Africa has a small population, and for agricultural production on more than a small scale has to depend on the absorption of the products by overseas markets. The small home consumption and the dependence on export have had strong influences on agricultural development. For success in an export trade it is essential that the costs of production and of transport be low, and, owing to the intensity of competition from other countries, that the quality of the products be good. The keeping of this balance between the cost of production and the returns on the overseas market is a serious problem for the agriculturalist. Up to the present it has often been the practice to invoke the aid of Government to enable export to be continued without loss. Though by far the largest part of the country is devoted to agriculture, the small population and the geographical position, far removed from suitable markets, have combined to render the industry not wholly economic. Without assistance in the form of protective duties, subsidised transport, or even direct subsidies, the economic balance between cost of production and market return has very often not been kept. The ability to give such assistance and maintain the economic stability of the country has been possible on account of the great development of mining, and especially gold mining, which has provided the real basis on which all other developments in the country depend.

The lack of a proper economic development in agriculture cannot be attributed solely to the necessity for, and geographical difficulties of, overseas markets. Farming methods have by no means always been the most suitable or have not fully kept pace with changing conditions of marketing and transport. In some cases procedure that was first adopted when home consumption alone was aimed at has been continued with little alteration under the new conditions. The necessity for keeping cost of production low has often appeared as an encouragement to this sort of conservatism.

Other influences have also contributed. The need to produce

material of sufficient quality has not always been appreciated, and in some cases, for example wine, the lack of real standardisation of products has operated adversely on the overseas markets. Another influence operating in the same direction has resulted from the attempt to increase the quantity produced without consideration of the other results, which later may lead to decrease in quality or in quantity, or both. An example may be taken from cattle rearing. The number of animals has been increased without proper reference to the fundamental necessity for maintaining a balance between consumption and growth of the plants, with the inevitable result that pasturage has deteriorated, in too many cases very seriously. In the grazing country the problems of maintenance and regeneration of pastures have become serious and demand immediate careful study. The point of most importance is the regulation of grazing so that the consumption by animals never exceeds the amount of vegetation currently produced. Where interference with the natural development of the vegetation has not been allowed to become serious, such regulation may be sufficient to maintain a suitable pasture. More often it is necessary to allow a period of rest for recovery of the grassland. This can very often be attained by paddocking and rotation in the grazing of the plots, so that each has such a rest period. Where more serious degeneration has taken place more drastic measures may have to be taken, but in all cases a knowledge of the natural succession of the vegetation should be the guide. Economically it is not always possible to allow sufficiently prolonged rest periods to allow of natural regeneration, and the cutting out of noxious weeds and, in some cases, actual planting of grasses must be undertaken.

In parts of the more arid grazing regions there is definite overstocking and a reduction is essential unless the whole area is to deteriorate seriously. The overstocking is shown in the changes that are occurring in the vegetation and in the very large losses of stock that occur in periods of rainfall shortage. The last is a definite feature of the climate, though its recurrence is not very regular. The temptation to increase stock to a maximum during periods of favourable rainfall is very great, but as soon as the numbers rise to a point where consumption exceeds the average production of fodder ultimate loss and deterioration follow.

In regard to pasturage, there is another aspect to be considered

which has received attention only within the past few years. Much of the grazed vegetation has a rather low nutritive value and is unable to maintain stock of the required quality unless artificial additions are made. The lack of nutritive value does not run parallel with general growth rate, some of the more arid parts producing herbage of better value than areas with much better rainfall. Lack of phosphorus is a very general condition and the practice of supplying bone meal as part of the rations is becoming more and more general on the better farms. The introduction of exotic fodder plants has been tried so far only on a small scale, but some good results have followed the practice. Planting grasses either in impoverished pastures or in pastures treated with fertilisers would probably increase their nutritive value. For the production of high quality in products, the growing of fodder plants to supplement the diet is probably desirable.

In crop production the average yield per acre over the country is low for grain, fruit and other crops, when compared with other producing countries. The low yields are due to more than one factor; prominent are poverty of the soil and sparing use of fertilisers. Practically all the cultivated soils are deficient in lime and in phosphorus, very often also in potash, and the nitrogen content is low. Nitrification is generally fluctuating and far from continuous through the year. For the production of soils of a fertility really comparable with those of other countries whose products compete in the markets, additions of manures are essential. Without them neither quality nor quantity can be maintained at a suitable level. In the growing of grains, rotation of crops is not generally practised. Instead land is left to lie fallow for a period, a practice that is not favourable for the retention of good fertility in the soil. For fruit culture more intensive methods are practised, green crops are ploughed in, but, even so, further additions are generally needed. To bring yield up to a proper level, and at the same time to obtain good quality, still more intensive methods are needed than those usually practised both in regard to soil fertilisation and to the selection of suitable varieties and their tending during the year. The enormous contrast that appears at present in the yield and quality of crops on the more progressive farms and those in the same region that are less progressive, shows what can be done.

The general trend of the measures that seem to be necessary for

the maintenance and the improvement of the pasturage and for the increase in the yield and quality of crops is undoubtedly towards a raising of the costs of production, but unless such steps are taken the retention of export markets will be difficult. In many cases, if not in all, the increase in yield and quality would soon more than compensate for the increased expense of production. The whole future development of agriculture appears to be dependent on the adoption of more scientific and intensive methods.

There are considerable possibilities for development in water conservation and irrigation in different parts of the country. On a large scale such schemes can only be carried out by the State, but there are a large number of smaller streams and channels where regulation and the conservation of flood waters might provide much valuable land for cultivation.

Afforestation.—The country has a very pronounced lack of timber and there is great need for increased production. The indigenous trees, though many are valuable as timber, are all slow-growing hardwoods, and very few are at all suitable for growth in plantations: exotic trees must be relied on for the enlargement of the timber supplies. The planting of these exotics often has a very great effect on the native vegetation, in extreme cases even leading to its extinction.

Much of the naturally treeless part of the country can probably never be afforested economically on account of frost or drought or both. There are, however, large stretches which are well suited to the growing of trees and in which certain exotic species grow very well.

It is often claimed that the planting of trees will have an ameliorative effect on the climate in regulating temperature fluctuations and increasing the general humidity. Where the climate is one in which evaporation exceeds precipitation it is very doubtful if such an effect will follow except where the plantations are extremely extensive. Indeed the creation of plantations, and especially the creation in or around water catchment areas, is often opposed on the ground that the water supplies will be actually decreased. An appreciable reduction in soil water content has been shown to follow the planting of certain exotic trees in the Knysna region, and should this follow planting in areas less favoured in rainfall the results might be serious.

The whole problem is one urgently needing investigation. Especially in areas which are, or should be, used for water conservation investigations are needed to determine the realities of the relations between plantations and water supplies. Should the results of such investigations be adverse they must still be balanced against the enormous demand for timber and the unquestioned value of trees as soil binders and soil retainers.

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See also Chap. I, Nos. **(1)**, **(4)**, **(5)**, **(6)**, **(7)**, **(9)**; Chap. III **(2)**; Chap. IV **(19)**, **(20)**, **(21)**; Chap. V **(4)**, **(5)**; Chap. VI **(3)**; Chap. VII **(13)**, **(15)**; Chap. VIII **(1)**, **(6)**, **(7)**, **(8)**, **(9)**.

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