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DEPARTMENT OF AGRICULTURE
DIVISION OF BOTANY

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A Botanical Survey *of the* Keiskammahoek District

By

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FOREWORD

The Native rural area of the Keiskammahoek district, in the eastern Cape Province, is well favoured by nature. One would not think so, however, to see it in its present state. Less than a century ago a good rainfall fed numerous perennial mountain streams; extensive stretches of rooigrass clothed the mountain plateaus; patches of indigenous forest flourished on mountain slopes, and excellent arable land was present in the valleys. As Schonland said in 1927, "One would think that there would be a land of milk and honey". But the natural resources of the area have not been treated wisely and there has been an alarming deterioration in the productivity of the area during the past 50 years.

In 1946 the National Council for Social Research decided to sponsor a study of the social conditions of the Keiskammahoek district as a sample Native rural area. Professor R. L. Robb was appointed Director of the project, which, from the beginning, was planned on as wide a basis as possible. The Division of Botany and Plant Pathology was approached for assistance on the botanical side and Mr. R. Story, then recently appointed as Botanical Survey Officer in charge of the Eastern Cape Province, with headquarters at Grahamstown, was made responsible for this aspect.

With characteristic thoroughness Mr. Story applied himself to his task and the present work is the result. The study became almost a full-time occupation for four years. In consequence of the detailed nature of his report it was decided to include only a brief summary in the official record of the National Council for Social Research and to publish the full account in our own series of Botanical Survey Memoirs.

Mr. Story's work is a model of careful investigation. He illuminates the path to a rational system of veld management, in the Keiskammahoek district in particular, but his results have a far wider field of application. He marshals many facts of fundamental importance on the ecology of *Acacia karroo* and these have an important bearing on Acacia scrub control throughout the Union. The full report should be studied carefully by agricultural officers and social planners. His main conclusions and the chapter on Economic Botany and Points of General Interest should be read by all.

R. A. Dyer.
Chief: Division of Botany and
Director of Botanical Survey of
the Union of South Africa.

Pretoria,
2 *January* 1952.

ACKNOWLEDGEMENTS

My sincere thanks go to the people mentioned in the text who have given me help with these investigations. I am indebted besides to Dr. R. A. Dyer for the complete freedom he has allowed me, and for the information obtained from his photographs, manuscript reports and verbal accounts of the early history of the experiments with *Helichrysum argyrophyllum*. My fellow-members of his Division have been of help in supplying reference books, in determining and checking the plants collected and in processing the photographs. To Dr. L. E. Codd in particular I express my thanks for his quick and willing responses to numerous requests for apparatus, and for acting as intermediary between myself and various Government departments. Mr. J. P. H. Acocks has given me the benefit of his specialised knowledge, and has allowed me to make use of his unpublished work.

Miss L. L. Britten undertook the checking of this paper and suggested many valuable improvements. I am grateful to Prof. Robb and his staff for help with transport and typing, and for many kindnesses, and to the staff of the Department of Native Affairs for assistance in overcoming the practical difficulties connected with the field work, and for information also, regarding the veld and its history. Through the co-operation of the Director and staff of the Division of Meteorology, who supplied the instruments, extracted the figures from the charts and were at all times ready with advice, it was possible to do the climatic investigations summarised in Chapter 1. I gratefully acknowledge this assistance, and that of Messrs. R. A. Hoyle and F. J. Junor, who reduced the figures to their final form. I thank the Grahamstown staff of Messrs. African Explosives and Chemical Industries for the loan of apparatus, and Mrs. A. J. Harris especially for her assistance with the typing.

I referred continually to the herbarium and library of the Albany Museum while doing this work, and acknowledge with thanks the help extended to me by the Director, Dr. J. Hewitt.

CONTENTS

INTRODUCTION

The foundation for this work was laid early in 1947, when I was appointed Botanical Survey Officer for the Eastern Cape Province, with headquarters at Grahamstown, and began vegetation studies with special reference to the encroachment of Acacia scrub.

In that same year, the National Council for Social Research drew up a plan for investigating the conditions of Native life in the urban and rural areas of South Africa. As representative areas there were chosen respectively a Native township in the Transvaal and the Keiskammahoek district, which is situated in the Eastern Cape Province in a direct line about 100 miles north-east of Port Elizabeth and 50 miles north-west of East London. The district was chosen mainly because of the conditions of general poverty in this area. Other points in its favour as a research centre were its size of 220 square miles, making it large enough to yield reliable information without being unwieldy, its importance as a catchment area, the convenient situation of the town in its centre, and the fact that it is within easy reach of Dohne Agricultural Experiment Station, Rhodes University, Fort Cox Native Agricultural School, Fort Hare Native College and Lovedale and St. Matthews Missionary Institutions.

At the request of the Chief, Division of Botany and Plant Pathology, I took part in the investigations at Keiskammahoek, which investigations began in December 1947 under Prof. R. L. Robb, and continued until the end of February 1951. Among the matters studied were the economic and sociological organisation, health, nutrition, education and land tenure of the Native people, and the geology, topography, soils, climate, water supplies and vegetation of the district, the last being the subject of this paper.

Although the botanical survey is of the Keiskammahoek district, it has not been limited strictly to that area. Many of the features noticed have a wide application, and to have studied them solely with respect to Keiskammahoek would have been to gain sometimes an inadequate impression or even a wrong one. Hence the plants and communities of the district have been examined outside it also, wherever they have been found, and comparisons made with similar or related communities.

The observations are true in general only. As there are no known inflexible rules governing the behaviour of plants and animals, the fact can never be lost sight of that exceptions are bound to occur. They have been recorded as far as they are known.

As to the composition of the original vegetation, the conclusions drawn lack any certain knowledge of the influence upon it of the big and small game which was in former days plentiful over the eastern Cape. There are few records of such matters to be found and few facilities now for studying the animals at first hand.

For convenience of description, the vegetation has been divided into woodland and grassland, treated first separately and then together, and various types of these two divisions are considered. Some important species are singled out for special treatment. The term *woodland* is used according to the definition given in Carpenter's *Ecological Glossary*—"areas whose vegetation is composed essentially of woody plants".

To avoid repetition in the text, a glossary has been added containing the available common names which apply, and explanations of some technical terms.

Results have not been statistically analysed, and can therefore serve as indications only.

CHAPTER I

THE AREA AND ITS CLIMATE

The history of the district is included in the works of Theal and Cory, which deal with South Africa as a whole, and there is in addition a report by Jubb (1945) which is confined more particularly to Keiskammahoek. In this botanical survey the relevant historical records are mentioned in the places where they have a direct bearing upon the vegetation under discussion.

The topography and the geology have been studied by Mountain, and the soils by Murray. Their papers are to be published by the National Council for Social Research, Pretoria. I am indebted to the authors for their permission to incorporate the following short summaries which I have made from the manuscript reports.

TOPOGRAPHY

The district is roughly circular in shape, in diameter 16 miles and bounded by a ring of mountains which on the northern border are mostly over 5000 feet above sea level and have as their highest point the peak of the Third Hogsback, of 6360 feet. On the east and west, offshoots of these mountains slope down to meet the foot-hills of the southern border where the altitude is for the most part about 3000 feet. The range of altitude is 4760 feet. The basin is hilly and much dissected, and is drained by four main streams, from east to west the Rabula, the Keiskamma, the Gxulu and the Wolf, which after uniting within the district leave it on the south-western side under the name of the Keiskamma River.

GEOLOGY

The three geological formations are:—

(3) Alluvium.
(2) Dolerite.
(1) Beaufort Series.

The Beaufort Series "represents a conformable sequence of sedimentary rocks varying in character from mudstone to sandstone. . . . These sediments dip fairly uniformly over wide areas at angles up to about three degrees towards the north."

Dolerite intrusions, in the form of dikes and inclined sheets, cover 25 per cent of the total area. The dikes, varying in thickness from a few inches to hundreds of feet, are found throughout the district. Of the sheets, three main ones occur, the most southerly of these, which has been named the Zanyokwe sheet, running from Burnshill eastwards to the plateau immediately north of Debe Nek. The second, named the Nqhumeya sheet, is wide and irregular. In the east it extends to Schwarz's Krantz, just east of farm 334, and to the west it runs through Nqhumeya and the Boma Pass to turn up the Wolf River Valley, the base crossing the Wolf and continuing to below Mount McDonald. The third sheet begins near Gxulu Kop, crosses the Mnyameni River Valley and continues eastward a little north of St. Matthews, following a zig-zag course until it crosses the Dontsa Pass, after which its trend is in general southwards. It has been named the Nqolo-nqolo sheet. In addition to these three sheets, there is a complex arrangement of minor ones in the extreme north of the area.

There are on the whole, few flood-plains, and nearly all the alluvium is confined to the main water-course, the Keiskamma River.

SOILS

The soil types conform very closely to the geological structure. They are "residual and formed *in situ*. Owing to the mountainous topography, however, there has been much colluvial drift, with the result that certain soils have been displaced far from their seat of origin." The sedimentary rocks give rise to soils agriculturally inferior to those derived from the igneous rocks. They are shallower, contain fewer plant nutrients, are prone to wind and water erosion and may be waterlogged in the rainy season. They may be divided into:—

(1) Shallow gray loams with ferruginous concretions from a few inches to a few feet below them. They are easily damaged by sheet erosion and are not suitable for cultivation.
(2) Gray loams on clay, which are deeper soils, deficient in plant foods. They produce poor crops and have a tendency to become eroded into gullies.
(3) Yellowish-brown sandy loams on sandstone, occurring in small quantities.

These three together make up about 58 per cent of the total area.

The dolerite soils, which make up about 38 per cent, generally withstand ill-treatment better because of a better structure. The following may be recognised, but there are many intermediate types.

(1) Immature black clays one to two feet deep, containing boulders. They are suitable for cultivation where deep enough.
(2) Deep red clays, chocolate when virgin, red after cultivation, 6 feet deep and more, and found on the sunny side of dolerite ridges. As they are rich in plant foods except nitrogen and as they are not very erodible, they are eminently suitable for cultivation.
(3) Black, well-developed deep clays, forming more or less level plains.

Alluvial and alluvial-colluvial soils are the most fertile, have a good structure and are the most sought after by Natives for cultivation, but make up only 4 per cent of the total area.

VEGETATION

The vegetation of Keiskammahoek is predominantly woodland. In the lowlands it consists of bush and scrub, which vary in character according to the rainfall and the temperature and which may be divided into four types differing from one another fairly clearly. On the middle mountain slopes are the forests, more uniform than the scrub and bush but divisible nevertheless into a dry and a moist type. In the regions of high rainfall above the forests is found the macchia, which extends to the tops of the Amatole range.

Grassland is found in exposed positions throughout the district, but because of uncontrolled grazing much of it has been seriously damaged, and large areas have been invaded by inedible weeds. The most important of these is *Helichrysum argyrophyllum.*

Murray's soil map shows that there is no apparent relation between soils and vegetation. A few plants do show a preference for a particular soil but any character which they may impart to the vegetation is lost under the overwhelming influence of the climate, and can be brought out only with detailed study. It is emphasised that these remarks refer to Keiskammahoek only.

CLIMATE

GENERAL

Through the kindness of the Director of Meteorological Services, it was possible to set up five meteorological stations in the district. They were placed in order:—

(1) In macchia, on the lower south-east slopes of the Hogsback, at an altitude of approximately 5300 feet. The macchia, about 3 feet tall, consisted mainly of *Cliffortia paucistaminea.*
(2) In Helichrysum on the Wolf Plateau, at an altitude of about 4800 feet, on ground dipping slightly towards the north, 390 paces from beacon C at a bearing of 16° magnetic (355° true).
(3) On the border of high forest (type 6) at Wolf Ridge Forest Station, 4000 feet. The screen was set up on the lawn outside the office.
(4) On the border of dry forest (type 5) at Lenye Forest Station, about 2500 feet. The screen was in a small clearing between the forest and the thorn scrub which borders it, on a gentle grassy south slope.
(5) In scrub at Fort Cox, 1775 feet. The screen was first on a Kikuyu lawn and later in a small grassy clearing about a hundred yards from the first position. The move was made necessary because of the dusty conditions near the Kikuyu lawn.

The positions of these five stations are shown on the map which accompanies this paper. At each was a Stevenson screen containing a thermograph and a hygrograph, operated under the standard conditions recognised by the Division of Meteorology. The stations were maintained for a year, from 1st September 1948 to 31st August 1949, and the readings of temperature and humidity are set out in the tables and graphs which follow. The readings are comparable among themselves only. They cannot stand alone, for one cannot rely on the accuracy of means obtained from less than 35 years' observations (Kendrew, 1922).

The only records considered were those which were unbroken at all stations for a full day of 24 hours reckoned from midnight. The gaps in the year's records were as follows, dates inclusive:—

For humidity	*For temperature*
Sept. 19–23	Sept. 21–23
Oct. 6–Nov. 15	Oct. 10–12
Nov. 27–30	Oct. 18–Nov. 15
Dec. 10–12	Nov. 27–29
Dec. 18–30	Dec. 18–24
Jan. 1–5	Jan. 3–5
Jan. 16	Jan. 27–28
Jan. 27–28	Feb. 2–21
Feb. 2–21	Mar. 4–5
Mar. 4–5	Mar. 14–15
Mar. 14–15	May 2–6
May 2–6	May 12–18
May 12–18	May 20
May 20	May 23–June 28
May 23–June 28	July 11–14
July 6–8	July 21
July 11–14	July 27–29
July 19–Aug. 17	
Aug. 27–28	

The twelve months included a mild winter, the lowest minimum temperature recorded being one of 26°F in the Helichrysum, which would probably make the temperature at ground level somewhere near 21°F (Whitmore, 1949). There was no snow, and no freezing of the ground was noticed, but both are common occurrences above the forests on the Amatole Mountains as a rule. During cold spells the ground may remain frozen through the day and the traces of its freezing are widespread. The most conspicuous is a puffy and fissured appearance of the soil, another less conspicuous is the aggregation of small stones where the ground is level and exposed. Locally the stones may be about the size of an orange, and downwards, and their aggregation (into areas a foot or two in diameter) appears to be caused by the movements set up in the soil when it freezes and thaws (Polunin, 1934, p. 353). This phenomenon, known as solifluction or frost heaving, is well known in arctic and alpine regions, and a comprehensive list of literature references is given by Hanson (1950). As it is slight at Keiskammahoek, it would remain unnoticed by anyone unacquainted with it, and I am obliged to Dr. E. Archibald for pointing it out to me on the escarpment east of Chatha Forest Station.

The twelve months coincided also with a period of drought, from the point of view of those who read the instruments fortunately so, for the station at Fort Cox was the only one easily accessible in wet weather. The macchia and Helichrysum stations were especially difficult to reach. To give them their routine attention entailed a climb and a walk of about five miles in all and took 3½ hours under the best conditions. The featureless Wolf Plateau was sometimes under thick mist, which could reduce the visibility to 15 yards. When this happened it was necessary to travel on a compass bearing which had been established previously.

A paper on the Keiskammahoek climate by Pilson and Higgs (ms.) gives rainfall and temperature figures and includes a general discussion. Among the points brought out are the following:—

(1) The best rains fall in March.
(2) Set-in rains are probably mainly from the south-east.
(3) Snow on the mountains falls three or four times in winter. It rarely extends below 4000 feet.
(4) The north-wester is a winter wind, almost invariably hot and dry.

Supplementary observations are as follows:—

HUMIDITY

The hygrographs gave continuous records of the relative humidity, but these measures are imperfect because, as Mayer and Anderson put it (1940, p. 194) "with the same relative humidity, evaporation from moist surfaces exposed to the air will be many times as rapid at 50°C as at 10°C." The readings would have been comparable only if the air temperature at each station had been the same. This did not happen during the year, and would have been a freak occurrence if it had happened, and for this reason the relative humidity readings are not given. Together with the current air temperature, they were used instead to calculate the saturation deficit, according to the formula Saturation Deficit $= D\left(1-\frac{RM}{100}\right)$, where D is the saturated vapour pressure at the observed temperature and RM the relative humidity (Henrici, 1926). The saturation deficit is a measure of dryness, and has the advantage that it is a definite measure in itself, without the need of complementary readings. It is not directly proportional to the rate of evaporation, and still less so to transpiration, for transpiration is evaporation plus the added complexity of life. Nevertheless, to say this is not to say that a relation does not exist. It is there, but it is a complicated one (Maximov, 1929, p. 161) and "the whole problem of atmospheric moisture in relation to ecological problems is still far from being

Fig. 2—Daily Range of Temperature in Degrees Fahrenheit.

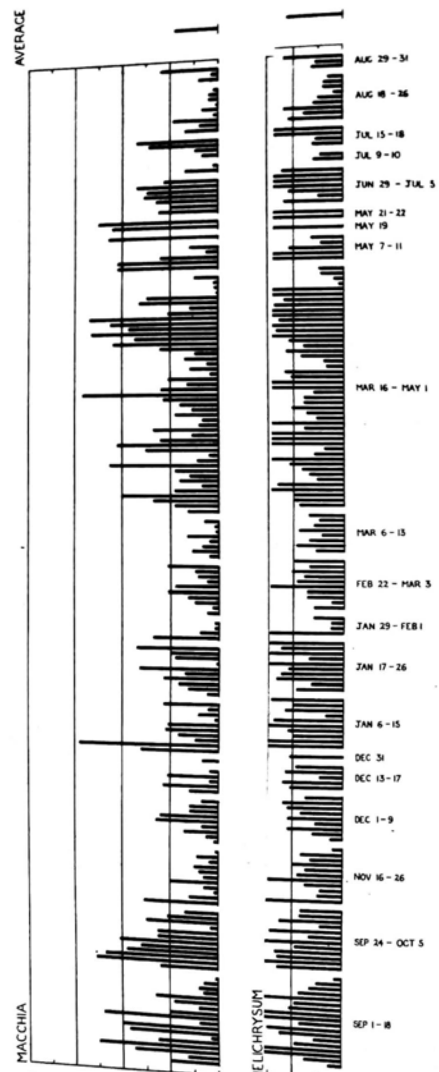

Fig. 1.
DAILY
SATURATION DEFICIT
IN INCHES OF MERCURY
SEP 48 - AUG 49

solved" (Thornthwaite, 1940, p. 27). Some common errors concerning this subject have been pointed out also by Leighly (1937). All that can be said at present is that a high saturation deficit indicates a dry habitat.

Monthly and yearly averages of the saturation deficit, computed from readings taken every two hours, are set out in Table 1 and Figure 1. There are no great differences between the stations, and no consistency in their relative order of dryness, the only consistent feature being the increasing dryness at all of them during the winter. The average saturation deficits for the year are also remarkably uniform, as has been pointed out on page 124. It appears therefore that the dryness of the atmosphere is of only minor importance in its influence on vegetation at Keiskammahoek.

TEMPERATURE

Records of temperature are set out in Tables 2–10 and Figure 2. The following are the noteworthy points:—

Average Temperature

There is practically no difference in the readings at the macchia and Helichrysum stations, and these two sets are consistently lower than those of the other three stations. Of these other three, moist forest, dry forest and scrub are warmer in order except during mid-winter (May, June and July), when the dry forest is the coldest. As this station was the only one situated at the foot of a mountain, it is possible that the low winter temperatures were caused by the lodging of cold air, but it is not clear why this did not occur during the summer as well.

Temperature Range

The average diurnal range was calculated for each month, with the results given in Table 7. It was invariably least in the macchia, increasing in order in the Helichrysum, moist forest, scrub and dry forest. The same general pattern is apparent in the monthly and annual ranges (Table 8).

Figure 2, besides showing the greater extremes of daily temperature in the lowlands, shows too that the difference between summer and winter temperatures is there much greater than it is in the highlands. On the whole, temperatures in the lowlands are warm and fluctuating, in the highlands cool and even. At all stations the summer rise of temperature begins in December and the winter drop in May.

Minimum Temperature

The absolute minimum (Table 5) and the average daily minimum (Table 6) were both generally lower in the highlands than in the lowlands, with the moist forest intermediate.

The times of occurrence of the minima were at first plotted separately for winter and summer, according to Tables 9 and 10. As the two histograms for each station were found to differ only in detail, they were combined as shown in Figure 3.

In the mountain stations the minima occur at midnight far more than at any other hour—in fact, there are about as many occurrences at midnight as there are at all the other hours combined. The next most common occurrences are in the morning, not directly after midnight as one would expect, but at 5 or 6 o'clock.

In the two lowland stations there is again a concentration of minimum temperatures at midnight, but less so than on the mountains. On the other hand, the occurrences in the morning are decidely more marked, and slightly later.

The reason for this distribution of the minima is probably bound up with cold air drainage (see pages 36 and 38). It is suggested that in the absence of complications caused by cold air drainage, the usual time of occurrence of the minimum temperature is at midnight. When cold air drainage takes place, it does so from the peaks of the mountains, and its effect must accordingly be slight and soon perceptible near the peaks and stronger and later perceptible at places progressively lower. This theory is in agreement with the results shown.

The higher lowland minima are probably due in part to the compression and consequent warming of the cold air stream as it descends from the highlands. The rise in temperature is about 1°C for every drop of 100 metres, or 5½°F for every 1000 feet (Hann, 1903, quoted by J. Phillips, 1931, p. 52).

It is of interest to note that Figure 3 gives definite grounds for the belief that the coldest temperatures occur at sunrise.

Maximum Temperature

There was little difference in absolute maximum between the two upper stations or between the two lower ones (Table 3), and this was true also of the average daily maximum (Table 4). The lowland maxima were higher, usually by about 15°F.

As the times of occurrence of summer and winter maxima were shown to be essentially the same, the two were combined in the same way as the minima.

At all the stations the maxima occur mainly in the early afternoon, there being an abrupt rise in their frequency from 1400 hours (2 p.m.).

In the mountain stations there is in addition a marked grouping of the maxima at and near midnight, which may possibly be explained by a complication which sometimes follows upon cold air drainage, and which is discussed on pages 36 and 38. The complication comes about when the warm air which rises from the valleys settles in the highlands in the place of the cold air which has drained away. The exact causes which determine this circulation depend upon local conditions, and, according to the records, are unconnected with the season.

It is noteworthy that the midnight grouping is perceptible also at the scrub station at Fort Cox, which is on a ridge and therefore subject to the same phenomenon, localised, and thus on a smaller scale.

The dry forest station was on a gentle slope of 3 degrees, from which it follows that localised circulation of the air in the manner discussed would be very slight. The near-midnight maximum was recorded only twice.

RAINFALL

Rainfall figures for ten stations in and around the district are given in Tables 11–13. All the stations have about 70 per cent of their rain during the summer (October to March inclusive), and there are no unusual features.

It was at first thought that Helichrysum areas might owe their existence to a lower rainfall than fell on macchia areas, and to investigate this, three mountain gauges were set up in macchia and two in Helichrysum, as follows:—

(1) In macchia, at the meteorological station on the slopes of the Hogsback, at about 5300 feet.

(2) In macchia, in Sonntag's protection plot above the Chatha plantations, at about 4700 feet.

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(5) In Helichrysum, on the wide terrace which lies on the mountain north of the Dontsa plantations, at about 4650 feet.

Results are given in Table 14. They suggest that rainfall is unlikely to be the deciding factor between macchia and Helischrysum, and add support to the views given on page 115 on the interrelations of these two communities.

For interest's sake, the rainfall from other gauges in the neighbourhood is given for the same period.

Table 1

AVERAGE SATURATION DEFICIT CALCULATED ON 2-HOURLY READINGS

(In Inches of Mercury)

Month	Days	Macchia		Helichrysum		Moist Forest: Wolf Ridge		Dry Forest: Lenye		Scrub: Fort Cox	
		Total	Average	Total	Average	Total	Average	Total	Average	Total	Average
1948:											
September ..	25	75·5278	·2518	76·8182	·2561	85·9928	·2866	78·1013	·2603	82·0175	·2734
October ..	5	10·9569	·1826	10·5823	·1764	10·5571	·1760	14·5797	·2430	11·5402	·1923
November ..	11	13·8175	·1047	12·8364	·0972	15·7733	·1195	26·3190	·1994	23·4879	·1779
December ..	15	21·6696	·1204	19·8738	·1104	28·6917	·1594	42·5002	·2361	32·1944	·1789
1949:											
January ..	23	49·5099	·1794	46·0812	·1669	56·4907	·2047	83·9265	·3041	67·0766	·2430
February ..	8	9·3054	·0969	7·5712	·0788	9·7621	·1017	16·7174	·1741	15·0231	·1565
March ..	27	50·6454	·1563	45·6806	·1410	58·6433	·1810	76·6404	·2365	67·4838	·2083
April ..	30	79·7781	·2216	77·8850	·2163	97·7957	·2716	87·1677	·2421	88·9705	·2471
May ..	9	27·4560	·2542	26·8399	·2393	33·0636	·3061	27·1865	·2517	30·9570	·2866
June ..	2	5·4109	·2255	5·0795	·2116	4·5816	·1909	4·5755	·1906	4·0670	·1695
July ..	11	28·7820	·2180	26·8399	·2033	35·3945	·2681	32·4044	·2455	32·8878	·2491
August ..	12	11·4082	·0792	12·6049	·0875	16·5822	·1151	22·0788	·1533	19·1513	·1330
Total ..	178	384·2677		368·6929		453·3286		512·1974		474·8571	
Average ..		·1799		·1726		·2122		·2398		·2223	

Note: Wolf Ridge, Lenye and Fort Cox represent woodland types 6, 5 and 2, respectively.

the minimum temperature is at midnight. When cold air drainage takes place, it does so from the peaks of the mountains, and its effect must accordingly be slight and soon perceptible near the peaks and stronger and later perceptible at places progressively lower. This theory is in agreement with the results shown.

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1948:											
September ..	25	75·5278	·2518	76·8182	·2561	85·9928	·2866	78·1013	·2603	82·0175	·2734
October ..	5	10·9569	·1826	10·5823	·1764	10·5571	·1760	14·5797	·2430	11·5402	·1923
November ..	11	13·8175	·1047	12·8364	·0972	15·7733	·1195	26·3190	·1994	23·4879	·1779
December ..	15	21·6696	·1204	19·8738	·1104	28·6917	·1594	42·5002	·2361	32·1944	·1789
1949:											
January ..	23	49·5099	·1794	46·0812	·1669	56·4907	·2047	83·9265	·3041	67·0766	·2430
February ..	8	9·3054	·0969	7·5712	·0788	9·7621	·1017	16·7174	·1741	15·0231	·1565
March ..	27	50·6454	·1563	45·6806	·1410	58·6433	·1810	76·6404	·2365	67·4838	·2083
April ..	30	79·7781	·2216	77·8850	·2163	97·7957	·2716	87·1677	·2421	88·9705	·2471
May ..	9	27·4560	·2542	26·8399	·2393	33·0636	·3061	27·1865	·2517	30·9570	·2866
June ..	2	5·4109	·2255	5·0795	·2116	4·5816	·1909	4·5755	·1906	4·0670	·1695
July ..	11	28·7820	·2180	26·8399	·2033	35·3945	·2681	32·4044	·2455	32·8878	·2491
August ..	12	11·4082	·0792	12·6049	·0875	16·5822	·1151	22·0788	·1533	19·1513	·1330
Total ..	178	384·2677		368·6929		453·3286		512·1974		474·8571	
Average ..		·1799		·1726		·2122		·2398		·2223	

Note: Wolf Ridge, Lenye and Fort Cox represent woodland types 6, 5 and 2, respectively.

TABLE 2

AVERAGE TEMPERATURE

Month	Days	Macchia	Helichrysum	Moist Forest	Dry Forest	Scrub
				Wolf Ridge	Lenye	Fort Cox
1948:						
September	27	52·5	52·8	56·9	58·2	59·8
October	14	49·6	49·1	52·9	56·4	58·4
November	12	53·8	53·2	57·6	62·7	63·8
December	24	58·8	57·8	62·4	66·8	68·1
1949:						
January	26	63·6	64·1	66·9	70·0	72·3
February	8	56·9	57·4	62·2	66·4	67·6
March	27	59·8	58·6	63·9	67·0	68·6
April	30	58·0	58·0	63·0	63·7	65·7
May	9	56·7	56·7	62·4	59·5	63·5
June	2	52·9	53·4	55·8	53·6	56·3
July	23	51·3	52·0	57·5	55·0	58·7
August	31	48·1	48·2	53·6	55·0	57·3
Av. Temp. for year ..		55·4	55·3	59·9	61·7	63·8

Note: **Wolf Ridge, Lenye and Fort Cox represent woodland types 6, 5 and 2 respectively.**

TABLE 3

ABSOLUTE MAXIMUM TEMPERATURE

Month	Days	Macchia	Helichrysum	Moist Forest	Dry Forest	Scrub
				Wolf Ridge	Lenye	Fort Cox
1948:						
September	27	81	81·8	88	93·2	95·5
October	14	71·4	71·8	78·9	84·7	85·7
November	12	78·6	79·5	85·1	92·7	91·2
December	24	81·1	80·6	85·1	92·3	90·5
1949:						
January	26	91·0	91·0	97·0	104·9	106·6
February	8	72·4	73·0	79·8	88·3	87·7
March	27	78·8	78·3	85·5	95·9	94·0
April	30	81·1	81·5	92·7	96·8	99·0
May	9	70·7	71·2	78·2	84·2	87·0
June	2	62·6	64·9	71·3	77·9	79·0
July	23	69·3	70·3	78·7	82·7	85·0
August	31	73·1	75·4	81·5	87·7	87·2

Note: Wolf Ridge, Lenye and Fort Cox represent woodland types 6, 5 and 2 respectively.

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TABLE 4.

AVERAGE DAILY MAXIMUM TEMPERATURE

Month	Days	Macchia	Helichrysum	Moist Forest Wolf Ridge	Dry Forest Lenye	Scrub Fort Cox
1948:						
September	27	62·5	63·3	68·6	73·8	77·0
October	14	57·4	57·9	61·5	67·6	69·0
November	12	63·8	63·9	69·4	76·5	76·4
December	24	68·4	68·1	74·2	80·3	80·9
1949:						
January	26	71·9	73·7	79·7	82·5	86·7
February	8	64·6	65·7	71·7	78·2	77·7
March	27	68·1	67·2	74·3	81·3	81·4
April	30	65·7	66·4	73·3	79·1	79·7
May	9	63·4	64·2	71·4	77·1	79·0
June	2	62·3	63·9	66·7	72·8	73·7
July	23	58·5	58·5	66·7	71·4	72·8
August	31	56·0	57·2	63·2	68·0	69·8
Av. daily Max. for year ..		63·8	64·5	70·5	76·0	77·5

Note: Wolf Ridge, Lenye and Fort Cox represent woodland types 6, 5 and 2 respectively.

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TABLE 5

ABSOLUTE MINIMUM TEMPERATURE

Month	Days	Macchia	Helichrysum	Moist Forest Wolf Ridge	Dry Forest Lenye	Scrub Fort Cox
1948:						
September	27	28·0	26·0	35·3	34·7	35·3
October	14	32·6	32·5	37·5	39·0	39·5
November	12	33·5	35·1	39·3	42·0	46·0
December	24	37·0	37·0	43·1	46·5	49·0
1949:						
January	26	45·5	44·0	49·0	46·0	50·0
February	8	44·1	40·5	48·9	52·0	58·5
March	27	43·2	42·7	48·0	49·0	50·5
April	30	37·1	37·5	42·3	45·0	40·0
May	9	41·0	38·3	45·5	42·8	44·0
June	2	45·5	42·5	44·4	39·8	39·7
July	23	32·0	33·0	36·5	32·0	34·7
August	31	30·0	27·5	36·5	35·0	37·0

Note: Wolf Ridge, Lenye and Fort Cox represent woodland types 6, 5 and 2 respectively.

Table 6

AVERAGE DAILY MINIMUM TEMPERATURE

Month	Days	Macchia	Helichrysum	Moist Forest	Dry Forest	Scrub
				Wolf Ridge	Lenye	Fort Cox
1948:						
September	27	40·3	40·1	45·2	45·8	46·2
October	14	41·5	41·6	45·9	48·1	49·7
November	12	43·8	43·9	48·8	50·9	53·8
December	24	49·7	48·3	53·4	54·8	57·9
1949:						
January	26	53·2	51·6	56·2	56·4	58·4
February	8	50·0	50·2	54·8	58·8	60·5
March	27	50·9	49·8	54·9	55·1	57·9
April	30	49·6	49·6	53·0	52·0	54·3
May	9	50·6	49·7	55·9	48·3	51·0
June	2	45·6	42·5	44·6	41·4	42·3
July	23	43·6	41·2	48·8	43·2	45·4
August	31	39·6	37·9	44·5	43·9	45·0
Av. daily Min. for year ..		46·9	45·6	50·6	50·2	52·2

Note: Wolf Ridge, Lenye and Fort Cox represent woodland types 6, 5 and 2 respectively.

Table 7

AVERAGE DIURNAL RANGE OF TEMPERATURE

Month	Days	Macchia	Helichrysum	Moist Forest	Dry Forest	Scrub
				Wolf Ridge	Lenye	Fort Cox
1948:						
September	27	22·2	23·16	23·4	28·1	28·7
October	14	15·2	16·2	15·6	19·5	19·2
November	12	20·0	20·1	20·6	25·9	22·6
December	24	18·7	19·0	20·8	25·8	22·9
1949:						
January	26	22·3	22·7	23·4	30·1	27·9
February	8	14·5	15·4	16·8	19·3	17·2
March	27	17·2	17·5	19·7	26·2	23·5
April	30	16·0	16·7	20·3	27·0	25·4
May	9	13·1	14·5	15·5	28·7	28·0
June	2	16·7	21·4	22·1	34·25	31·4
July	23	14·8	16·9	17·9	28·0	27·4
August	31	16·4	19·0	18·3	24·1	25·1

Note: Wolf Ridge, Lenye and Fort Cox represent woodland types 6, 5 and 2 respectively.

TABLE 9

TIMES OF OCCURRENCE OF MINIMUM TEMPERATURES

Hours																					
03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
3	10	15	7		1											1	2	5	7	9	32
6	7	9	10	8	5	2	2	1							3	1	2	4	4	7	34
4	10	9	15	2	1		1								1		1	2	6	5	36
5	7	5	8	5	3	2	1								1	3	2	6	8	3	47
4	6	9	23	6	7										2	1		2		7	33
3	7	5	7	6	12	5	3											2	3	7	43
	18	17	21	10	1													2	1	2	32
1	8	5	29	19	8	1											1	1	2	3	35
2	9	5	24	17	20	7	1	1											1	1	19
3	4	5	12	9	26	17	7	3						2	2	2			1	2	20

TABLE 10

TIMES OF OCCURRENCE OF MAXIMUM TEMPERATURES

		Hours																							
		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Macchia ..	Summer	1	3						2	3	5	3	12	10	29	24	13	2						1	2
	Winter	3	1				2					4	9	12	38	27	13				1		1	2	9
Helichrysum	Summer		1	2					3		5	5	17	12	23	20	17	2					1		2
	Winter	5	1								4	4	11	16	42	21	10				1		1	2	4
Moist Forest	Summer	2	2	1							4	2	2	13	23	20	26	10	2			1		1	1
Wolf Ridge..	Winter	5	2								2	2	5	11	27	30	25	8						2	3
Dry Forest ..	Summer		1								2	1	15	16	39	19	15	1							1
Lenye ..	Winter										1	4	7	15	49	35	11								
Scrub ..	Summer	1	1	1								2	6	8	20	16	23	18	12	2					
Fort Cox ..	Winter		2	1	1	1	1						2	8	23	17	27	16	16	5					2

TABLE 11

ANNUAL RAINFALL

	Fort Cox		Keiskammahoek		Dontsa		Lenye		Rabula	
	Rain	Rainy days	Rain	Rainy days	Rain	Rainy days	Rain	Rainy days	Rain	Rainy days
1930	22·33	56	24·34	61	31·55	89	27·50	79	29·52	87
1931	29·31	60	30·36	81	39·76	81	34·12	94	38·87	75
1932	27·02	65	25·48	60	33·78	111	31·63	78	31·85	81
1933	21·27	58	22·83	52	29·31	103	26·79	73	23·45	81
1934	28·89	68	22·79	47	34·28	95	33·91	86	33·10	83
1935	28·89	60	28·15	57	33·96	92	32·26	77	31·80	65
1936	25·42	63	22·96	56	29·66	97	28·50	88	28·97	68
1937	20·06	57	19·03	50	25·48	91	27·91	65	23·70	81
1938	23·38	63	27·67	73	32·40	107	35·46	94	31·52	90
1939	24·77	72	30·70	73	33·05	100	31·68	93	35·78	100
1940	22·65	51	24·43	56	23·78	93	33·11	75	28·68	74
1941	20·76	54	19·33	49	18·68	80	26·30	70	24·30	71
1942	24·79	87	27·50	68	26·29	96	32·18	82	32·11	77
1943	25·90	78	30·63	83	29·87	94	30·41	86	32·95	100
1944	21·43	62	20·76	63	19·38	82	24·04	75	28·41	75
1945	14·39	45	13·81	53	13·29	70	16·41	63	18·94	70
1946	21·50	68	20·05	58	22·17	99	25·29	92	26·87	92
1947	21·55	54	19·40	75	25·27	116	25·25	99	27·08	64
Mean	23·57	62	23·90	62	27·89	94	29·04	81	29·33	80
Winter rain	30%		29%		30%		30%		32%	

TABLE 12

SUMMER RAINFALL

(October—March inclusive)

Fort Cox		Keiskammahoek		Dontsa		Rabula		Lenye	
Rain	Rainy days	Rain	Rainy days	Rain	Rainy days	Rain	Rainy days	Rain	Rainy days
14·86	38	—		17·12	54	15·50	44	16·34	47
17·24	32	—		23·31	65	21·13	41	21·27	45
16·99	46	—		25·12	79	18·20	64	20·91	57
23·72	50	20·86	43	29·85	75	26·73	58	28·27	68
14·15	32	14·00	24	19·64	58	14·15	35	16·05	46
16·10	37	14·54	32	19·17	54	15·39	36	17·22	44
17·33	46	17·75	38	21·30	71	22·90	60	23·22	60
14·77	36	16·99	40	21·39	68	20·82	55	22·67	51
19·82	49	24·09	49	27·77	66	28·75	61	27·26	62
18·94	52	21·92	48	19·38	64	23·30	55	27·07	61
10·68	28	11·85	32	11·62	61	14·68	52	14·49	41
16·72	44	16·42	35	16·25	51	18·30	43	24·46	49
16·40	49	17·33	41	18·24	63	22·51	57	18·21	51
21·72	56	24·72	52	22·93	69	25·63	59	24·30	58
7·83	23	8·42	30	8·75	40	12·31	43	11·64	40
14·03	41	13·74	39	14·70	65	18·25	58	15·73	50
15·52	42	12·90	35	15·18	51	17·47	39	18·11	50
16·89	35	17·59	49	20·42	75	21·44	47	19·18	57
16·32	41	16·87	39	19·62	62·7	19·86	50	20·38	52

TABLE 12—(*continued*)

SUMMER RAINFALL

(October—March inclusive)

Year	Chatha		Wolf Ridge		Isidenge		Hogsback		Evelyn Valley	
	Rain	Rainy days	Rain	Rainy days	Rain	Rainy days	Rain	Rainy days	Rain	Rainy days
1930–31	20·50	66	24·21	56	26·25	74	34·19	48	44·68	66
1931–32	26·09	80	28·32	67	27·23	90	30·63	48	39·57	101
1932–33	35·15	87	30·73	65	30·40	96	29·40	52	46·26	94
1933–34	34·71	89	39·87	75	41·84	96	27·84	82	60·00	89
1934–35	24·40	68	24·19	56	26·14	76	27·54	71	47·41	88
1935–36	19·59	56	26·49	56	28·60	75	31·13	67	48·59	80
1936–37	25·88	59	31·78	75	38·99	101	41·52	79	63·33	84
1937–38	29·29	53	32·36	78	37·03	101	35·07	82	44·25	50
1938–39	36·52	59	40·99	83	43·42	96	48·56	97	55·92	91
1939–40	29·92	60	42·10	74	30·87	80	39·53	83	40·70	104
1940–41	26·04	53	28·69	73	28·71	75	32·48	66	34·86	100
1941–42	20·80	55	32·29	67	31·19	79	33·41	69	39·58	97
1942–43	32·87	54	29·21	72	24·50	87	28·78	71	42·48	92
1943–44	36·75	61	34·83	73	35·73	74	41·40	63	44·34	94
1944–45	17·40	49	19·47	57	18·71	57	19·35	50	26·85	87
1945–46	25·65	52	27·87	71	28·87	71	29·85	67	38·78	95
1946–47	24·23	48	25·77	63	28·34	76	31·83	64	33·48	89
1947–48	28·02	51	30·02	72	31·07	22	33·27	72	38·93	102
Mean	27·43	61	30·51	69	30·99	79	33·10	68	43·88	89

TABLE 13

WINTER RAINFALL

(April—September inclusive)

Year	Keiskammahoek		Fort Cox		Dontsa		Lenye		Rabula	
	Rain	Rainy days	Rain	Rainy days	Rain	Rainy days	Rain	Rainy days	Rain	Rainy days
1930	—		6·83	19	13·29	34	8·91	29	10·73	34
1931	—		9·85	21	15·55	22	13·36	43	18·17	33
1932	—		10·23	26	10·22	35	10·51	25	12·61	30
1933	4·50	11	5·50	15	5·47	28	6·35	21	6·44	22
1934	4·80	14	6·58	22	6·12	24	8·14	28	6·94	30
1935	13·78	28	14·48	30	17·20	40	16·30	32	17·93	32
1936	5·29	15	7·41	17	6·60	32	7·50	29	6·35	17
1937	2·81	11	3·35	18	4·40	23	4·41	17	3·87	24
1938	9·64	31	8·86	22	9·76	41	11·12	33	10·32	39
1939	8·21	27	6·41	28	9·97	36	8·60	38	9·05	40
1940	8·06	19	6·71	14	7·35	32	9·74	24	8·70	19
1941	5·32	15	5·77	19	4·95	21	6·59	22	7·16	24
1942	6·41	23	5·61	33	5·62	32	7·33	28	7·18	24
1943	10·24	30	9·63	32	10·06	34	10·75	33	12·59	41
1944	7·88	30	7·92	28	4·89	33	8·72	33	12·65	34
1945	3·65	15	2·66	12	3·61	21	3·28	22	3·54	22
1946	5·05	19	4·40	25	4·65	35	6·03	36	5·91	33
1947	6·90	34	4·93	18	8·24	47	7·82	45	8·53	25
Mean	6·84	21	7·06	22	8·22	32	8·63	30	9·37	29

TABLE 13—(*continued*)

WINTER RAINFALL

(April—September inclusive)

Year	Chatha Rain	Chatha Rainy days	Isidenge Rain	Isidenge Rainy days	Wolf Ridge Rain	Wolf Ridge Rainy days	Hogsback Rain	Hogsback Rainy days	Evelyn Valley Rain	Evelyn Valley Rainy days
1930	10·52	41	18·91	48	13·85	37	22·27	33	24·14	37
1931	13·87	43	18·38	51	12·68	37	17·98	29	31·22	44
1932	9·61	40	13·00	51	13·38	32	16·95	27	23·95	39
1933	7·67	26	8·29	40	9·90	32	9·30	31	14·81	36
1934	8·23	29	9·86	44	10·59	34	9·77	37	15·49	42
1935	16·85	40	21·56	53	20·34	40	21·93	51	17·91	58
1936	9·33	27	9·28	43	14·24	32	12·12	41	17·08	37
1937	5·14	15	8·03	34	7·23	27	9·09	36	10·67	28
1938	10·21	34	12·47	55	13·73	38	14·02	45	20·12	49
1939	12·20	40	12·66	48	12·06	42	15·69	48	15·57	53
1940	10·50	22	11·19	38	13·24	32	16·00	36	16·79	50
1941	6·39	23	9·09	34	8·59	28	9·41	33	11·16	46
1942	10·67	31	11·28	47	12·05	39	15·10	41	15·29	48
1943	12·52	28	15·87	48	14·21	39	18·40	44	21·55	54
1944	9·67	29	13·18	41	13·83	37	15·55	34	19·28	53
1945	5·36	21	6·76	35	4·22	31	8·67	30	9·79	47
1946	6·09	22	7·24	33	9·47	42	8·16	34	11·24	52
1947	9·91	37	11·60	55	11·00	52	15·85	51	15·98	65
Mean	9·71	30	11·26	44	11·92	36	14·26	38	17·32	47

TABLE 14

MOUNTAIN RAINFALL

(See text, page 115)

Period 18/8/48—3/11/49	ins.
Macchia, south slopes of Hogsback, c. 5300 feet	35·44
Macchia, Chatha West Ministerial Grazing, c. 4700 feet	35·06
Macchia, Mount Kemp, c. 4600 feet	29·66
Helichrysum, Wolf Plateau, c. 4800 feet	39·55
Helichrysum, north of Dontsa plantations, c. 4650 feet	30·21

RAINFALL AT NEIGHBOURING STATIONS

Period 18/8/48—3/11/49	ins.
Evelyn Valley	39·62
Hogsback Forest Station	39·15
Wolf Ridge Forest Station	30·36
Isidenge Forest Station	29·07
Chatha Forest Station	23·44
Lenye Forest Station	18·87
Dontsa Forest Station	15·37
Fort Cox	14·65
Rabula Forest Station	13·92
Keiskammahoek	13·67

CHAPTER 2

WOODLANDS

GENERAL

From the dry scrub which grows in the lower Keiskamma and Fish River Valleys one may proceed without a break through woody communities gradually becoming more mesophytic until they finally merge with the high forests of the Amatole Mountains, the forests in turn being in contact with the macchia on the upper mountain slopes. There is, for example, no interruption in the tree growth from the Fort Cox scrub (which includes such plants as *Euphorbia pentagona*) to the taller scrub on the west-facing slopes of Mount McDonald, the dry forest above it, and the moist macchia-bordered forests on the top of the Wolf Ridge, where *Xymalos monspora* is common; and this tree is, as stated by Sim (1907, p. 3) in his account of the Cape forests "the feature of the central damp recesses". This is confirmed by Bews (1916, p. 142; 1927, p. 15). Many similar transitions may be seen in the aerial photographs. It is not peculiar to the district and similar examples are widespread. One patch of bush on the south slopes of Stone's Hill, 4 miles east of Grahsmtown, changes from forest to dry scrub within a mile. At the upper limit of the bush in Buffelshoek, 12 miles north-east of Pearston, *Myrsine africana*, *Cassine aethiopica*, and *Gymnosporia acuminata* occur. The lower fringe contains *Carissa haematocarpa*, *Nymania capensis*, *Boscia albitrunca* and other species of the karroid broken veld (Acocks, in press). These points are brought out to show that a division of woodland into types is completely artificial. If this limitation is kept in mind, some arbitrary classification is nevertheless very convenient, accordingly the woodland in the Keiskammahoek area has been divided into seven types with the two extremes represented by Acacia scrub and macchia, and numbered from one to seven in order with increasing rainfall, as shown in the following table.

Type 1. Acacia scrub, widespread in the lowlands and abundant in the neighbourhood of Keiskammahoek Village.
Type 2. Fort Cox scrub, open, short and thorny.
Type 3. Nqhumeya scrub, taller and denser.
Type 4. Zanyokwe bush, with larger trees forming an unbroken canopy.
Type 5. Dry forest, as found at Lenye Forest Station.
Type 6. Moist forest, as found at Wolf Ridge Forest Station.
Type 7. Macchia, widespread over the highlands.

Because of the special economic importance of types 1 and 7, they have, in the pages that follow, been treated in greater detail than the others.

As the various methods of classifying woodland types have been summarised by Phillips (1928a) they need not be repeated here. Phillips himself employs the average holard as a criterion, but this method has not been used at Keiskammahoek because it is felt that there are too many objections to it. The most serious of these is the disproportionate amount of work involved in obtaining representative readings. Others are the difficulty of taking random soil samples in a forest and the fact that observations would have to extend over many years before irregularities arising from abnormal or localised climatic conditions would be smoothed out. In these studies it was found that the rain-

fall was a more reliable and convenient measure to use. It is a well-known fact that the water relations of the soil do not depend directly upon the amount of rain, but are bound up with a number of other matters. A good example of these is the nature of the prevailing rain, whether in the form of mists, drizzles, showers or storms. According to the form predominating, enormously different effects can be brought about, as may be realised if the Thames Valley is compared with the Bloemfontein area. The Thames Valley is well-watered and Bloemfontein is considered semi-arid, yet their average annual rainfall is very much the same in amount—25·75 and 23·5 inches respectively (van Reenen, 1923). A similar comparison has been made by Leppan (1928, p. 47). Other complications are caused by the texture of the soil, which influences the available water (Clements, 1905, p. 76), the wind, which increases transpiration (Schimper, 1903, p. 168), the plant cover, which is bound up with the run-off (Wicht, 1949, pp. 22, 34; Scott, 1949, pp. 126, 152), and the soil temperature, which may deny water to the plant even when the ground is wet (Warming and Vahl, 1909, pp. 194-5). However, most of these objections apply with equal force to the holard as well, and in practice it was found that under reasonably similar conditions of temperature and exposure a particular average annual rainfall was associated with a particular type of woodland.

With a few exceptions, the definite associations and consociations and their seral equivalents such as Phillips (1931, chap. 7) describes for the Knysna forests were not a feature of the Keiskammahoek woodlands.

In classifying the seven types, the following points were among the ones considered:—

(*a*) Rainfall;
(*b*) temperature;
(*c*) wind;
(*d*) successional stages, especially the later ones shown most clearly by the fringing species;
(*e*) trees present or absent and their frequency;
(*f*) habit and size of trees;
(*g*) definite canopy present or absent;
(*h*) associated animals;
(*i*) occurence of epiphytes;
(*j*) occurence of lianes;
(*k*) occurence of fungi;
(*l*) character and species of the undergrowth;
(*m*) limit of horizontal visibility;
(*n*) associated grasses.

The woodlands were studied firstly by making a reconnaissance of those in the district until an idea was obtained of how they might be expected to vary between the dry and the wet climates. Areas throughout were then examined in greater detail by means of general observations, and the listing (irrespective of frequency) of all the tree species observed and of the important species making up the undergrowth. This was done by crossing the area in various directions until the appearance of unrecorded species ceased more or less completely. The time taken varied from half a day to a day according to the size of the area and the luxuriance of the vegetation.

From those woodlands belonging to a particular type, one area was chosen as being the most typical representative and the composition of the trees was studied more intensively by means of belt transects, the positions of which are shown on the accompanying vegetation map. Types 1 and 7 (Acacia scrub and macchia) were omitted, firstly because their homogeneity made transecting rather pointless, and secondly because the method used for trees (types 2 to 6) could not be applied to the bushes of types 1 and 7 without giving a false picture of the communities. The areas in types 5 and 6 lie within the forest reserves and are closed to stock. The figures are not strictly comparable with those for the other types, where no protected areas were found. In the absence of any information as to the size of the sample area which would be required to give a statistically sound picture of the tree growth, an area of half an acre in each type was arbitrarily decided upon, and this was laid out across the centre of the patch. A good deal of trial and error established that 16 square yards at a time was the most that could be done, and the belt was accordingly made 4 yards wide and divided into four-yard lengths. The total length was 608 yards.

After unsuccessful attempts at marking out the transects with wire and tapes, the following method was evolved:—

Three reeds were cut to a length of 4 yards each. A starting point having been chosen, the direction of the transect was established and a reed was laid along it with its base on the starting point. The two remaining reeds were placed one at each end of the first one so as to form three sides of a square, and the position of the fourth side was judged by eye. When the square had been listed the first reed was moved forward 4 yards in the same straight line and the three sides of a fresh square were marked out, and so on until the end of the transect. Direction was maintained by compass. It was usually possible to pick up several small features like twigs, stumps and flecks of sunlight on the bearing, and by moving according to them to do without the compass except at intervals.

The counts were of the number of stems at breast height, whether they came from the same stock or not, for example a tree with a fork above breast height counted as one, but one with a fork below this level counted as two. The reason for this was that it was often impossible to establish which were unconnected stems and which were members of the same tree connected underground. The lianes in particular, at times buried and sending up branches from below the surface, gave rise to a very confusing maze of growth. Trees less than an inch in diameter at breast height were ignored. When uncertainty was felt as to the height of the taller trees, one of the reeds was used as a yard-stick, otherwise the heights were judged by eye with occasional checks to correct any gradual straying that might arise. The diameters were all estimated.

Extreme boredom towards the end of the day was probably the greatest source of inaccuracy, so much so that it was found advisable to stop working on the transects in the early afternoon. For this method of doing transects three workers are needed, one to determine the species and their measurements and two to do the recording and the shifting of the reeds.

It may be seen from the summarised transect figures given in Table 31, page 74, that there is a regular increase from type 2 to type 6 only in respect of the maximum and average heights of the trees. In other characters there is the same *general* trend of an orderly increase or decrease, but with minor irregularities. The differences are what one would expect to correspond with an orderly change in rainfall.

Various methods were tried and abandoned in an attempt to make an analysis of the different kinds of undergrowth. The main difficulties were the differences in habit of the plants concerned and the great complexity and variability of the community from place to place in the same area. The only possible method under the circumstances was a written description taking into account only the points of consequence and ignoring the great mass of detail which a complete analysis should bring out, simplify and rearrange according to its importance.

TYPE No. 1—ACACIA SCRUB

"Acacia" refers to *Acacia karroo* except where otherwise stated, and may include *Acacia hirtella*, *Acacia natalitia* and *Acacia inconflagrabilis*, for the

reason that the differences between them are not regarded by the writer as being of specific rank. The descriptions are to be found in the *Flora Capensis* and in a paper by Gerstner (1948). *Acacia karroo* is commonly known as "Mimosa".

THE SPREAD OF ACACIA

Places in the low-lying parts of the Keiskammahoek district are thickly covered with Acacia scrub, many being nearly valueless for grazing. The knowledge that these conditions are widespread indicated that a detailed study of this community and its relations would be of value in supplementing the work of Bews (1917a), Bayer (1933) and others. A common belief exists that such areas were once mainly grassland and that they have become overgrown comparatively recently. The following facts support this theory:—

In some areas now infested it was once so much of a rarity that farmers who wished to make brushwood stock kraals were obliged to send elsewhere for their material. Photograph 1 shows Acacia infestation on one of these farms today, the history of which is vouched for by the farmer who supplied the brushwood to its former owner.

Its rapid increase is striking on part of the Grahamstown commonage to the east of the town. Scattered over the northernmost 30 acres of the ground lying between the old and the new roads to Fort Beaufort are 29 mature trees, in height between 6 and 18 feet. The seedlings, of average height 2 feet, number just under 4400. As they have shown themselves capable of withstanding the exceptional drought of 1949, there is every reason for believing that they and their seedlings will in time densely cover the whole of this commonage. The drought referred to may be judged from the total rainfall registered at the Government Veterinary Laboratories, Grahamstown, from January to July inclusive. In 1949 it was 6·46 inches. The average for the last 15 years is 11·96.

A similar growth of seedlings in the Keiskammahoek area occurs on the slopes of the hill looking down on the Dontsa commonage from the south, that is, on the slopes north-east from point 3641. Although the younger generation is as yet only a few inches high, the growth is likewise dense. Counts indicated that there were up to seventeen to the square yard, in size from four inches down.

Pringle (1835) recorded Acacia in open formation near the source of the Baviaans River:—

> ". . . at the summit of an elevated ridge, commanding a view of the extremity of the valley . . . we beheld extending to the northward, a beautiful vale, about six or seven miles in length and varying from one to two in breadth. It appeared like a verdant basin, or *cul de sac*, surrounded on all sides by steep and sterile mountains. . . . But the bottom of the valley, through which the infant river meandered, presented a warm, pleasant and secluded aspect; . . . embellished without being encumbered, with groves of mimosa trees . . ."

Photograph 2, a view of the upper reaches of the Baviaans River, gives an idea of its appearance in 1951.

Encroachment in other parts of the country is referred to by Galpin (1926), Phillips (1930, 1935), Bews (1917a), Bayer (1933) and Scott (1949).

An apparent contradiction is provided by old postcards which include parts of the Keiskammahoek commonage and show that there was a thick growth round the town even in 1912, since when there has been only a slight increase in the particular parts which are visible. It is, however, definite that further from the town, spaces are now crowded that were clear in 1912. The photographs are not suitable for reproduction but numbers 98, 99, 264 and

265 in the files of the Botanical Survey section, Grahamstown, illustrate these facts. The inference is that round the town where grazing and trampling are more severe, the thorn scrub has more or less reached saturation point, but that it is encroaching still on the less accessible grasslands.

The evidence being thus wholly in support of an increase in Acacia, the question follows: since when has this been taking place?

Amm (1894) observed that its spread was proceeding "at an alarming rate" at Salem, and in the same year Greathead reported that a great many farms in the Fort Beaufort and surrounding districts were becoming overgrown with mimosa and "quite unfit for small stock". At Teafontein, between Grahamstown and Riebeek East, "Anti-Mimosa" (1896) regarded it, Cassandra-like, as "something to be reckoned with in the future unless prompt measures are resorted to", also as "a pest second only to prickly pear", and infestation was reported from the Somerset, Bedford, Adelaide and Fort Beaufort districts by Hobson (1896). Clear evidence of dense growth or encroachment thus goes back for 55 years, and one may safely assume that it has been troublesome for a good deal longer than this.

Bews (1917a) has shown that in Natal it is the forerunner of mixed bush, and this applies with equal force to the eastern Cape, especially on the steeper slopes and on stony ground. The significance of this will be discussed in Chapter 4. On flats, particularly where the soil is deep, and in exposed places, the Acacia tends to remain pure, at any rate for a much longer time. The Keiskammahoek postcards, by showing that there has been no influx of other species in nearly 40 years, indicate that it can be an enduring community under these conditions instead of a quickly passing phase. This point was missed by Bews, but similar behaviour is mentioned with reference to Natal in a paper by Bayer (1933, p. 281).

There are two pecularities about the unmixed and lasting Acacia thickets: firstly pure dominance is an extreme rarity in tropical and subtropical tree growth, especially in scrub (Phillips 1931, pp. 136, 169, 180; Bews, 1916, pp. 156–7), and secondly, the exclusion of other trees is not a characteristic of Acacia. As Bews (1917a) has shown, Acacia encourages their establishment. The fact that Acacia is South Africa's most widely-distributed tree (Sim, 1907, p. 212) suggests strongly that it is also the least exacting in its demands, and that it would often be the first to migrate into an unfavourable area. One could also expect to find pure and permanent stands more and more strongly marked according as the areas were progressively less suited to trees—obviously as far as these areas were not too unfavourable to preclude its growth altogether. Therefore the presence of homogeneous and stable Acacia thickets indicates, paradoxically, not an area suited to vigorous tree growth, but one where healthy grasslands might be maintained.

Bayer (1933) mentions also that in some areas of Natal, dense Acacia scrub alternates normally with grassland in the same place, and that these two communities have been replacing one another for long periods of time. So far I have been unable to find evidence for this cycle in the eastern Cape. The relationship between woodlands and grasslands is discussed in Chapter 4; here it may be stated that Acacia invasion is probably made easier if the way is cleared beforehand by the removal or weakening of the plants formerly in possession, and by a consequent lessening of competition. Dr. J. Phillips, in a personal letter, has stated his views as follows:—

"Disturbance (owing to reduced competition and higher soil moisture) accelerates the process of thicket development", and support for the statement regarding the soil moisture is given by the facts that in bare soil percolation is greater and loss of soil water less (Wicht, 1949, p. 22; Kramer, 1944, p. 545; Theron, undated, pp. 10–11, 16). Wicht's words are as follows:—

"... if two identical areas are available—one covered with vegeta-

tion and one bare—the loss from the vegetation will be greater than from the bare ground."

The vegetation is chiefly of use in shielding the ground from the force of the direct rain, in slowing down the speed of the run-off, and in holding the soil. The last point is true particularly of grassland, of which Clements (1935, p. 356) has stated "... grassland binds the soil with roots as no other community does."

Contrary to popular opinion, it thus appears that bare soil may be expected to have a higher moisture content than soil covered by grass—so long as any soil remains with the increased erosion that will take place, and provided that the top soil is not so severely trampled as to become impervious.

Additionally, the work of Howard (1925, 1940) shows that grass has a harmful effect on trees because of the high proportion of carbon dioxide in the soil air beneath it. Soil air under grass has up to twice as much carbon dioxide in winter and five times as much in summer as soil air under cultivation. The carbon dioxide inhibits nitrification and the formation of humus, and interferes with the normal activities of the mycorrhiza.

It would therefore be logical to suppose that Acacia would be better able to invade a bare area, and evidence in favour of this supposition is provided by the test described in the discussion on its establishment (page 50). See also photograph 3, showing grasslands in the Bedford district, treeless except for a growth of Acacia along the roads. In this neighbourhood there are many similar examples which indicate that the grass acts almost like a protective skin which has to be ruptured before the Acacia can grow. It is of interest to note that invasion by trees after destruction of the prairie grasses has been reported also from Illinois by Woodard (1925, p. 152).

USES AND DISADVANTAGES

The tree is useful in a number of ways and its timber was once, according to Pappe (1862) "extensively employed" for building purposes. He states also that the gum exuded is of value, but inferior to that of North Africa. In this he may be wrong according to a report in *The Farmer's Weekly* (27th April 1949) that a visiting English business-man is of opinion that it may be the "finest in the world" for sweet-making. MacOwan (1890) has published a short note on the gum and its collection. Its value as a fodder tree is well known and has been recorded by Marloth (1935, p. 53) and others, but this applies more to small stock, for cattle do not browse it readily. The bark is a good source of tannin, and was much used before the exotic Acacias were cultivated in this country (Sim, 1907, p. 59). Its branches in the Border area are at the same time effective and close at hand if material is required for silt traps in the reclamation of eroded slopes or gullies, and any grass seed so caught is favoured by light shade, and protection from stock as long as the thorns remain. These areas thus have a better chance of producing a quick cover. Small shrubby forms on parts which have been mercilessly overstocked can shelter and keep alive the grass species which have vanished from the surroundings, in this way providing natural nurseries from which the grasses may spread again if the veld is protected. Older growth, however, makes such heavy demands on soil water that other vegetation may be largely destroyed, especially when the trees are in dense stands (Bayer, 1933). As a temporary fence the branches are cheap and effective and often used for enclosing pasturage or cultivated lands. In a letter to *The Farmer's Weekly*, Hermenau (1949) gives an account of having made approximately 27 miles of such fencing over 2 years. In the cleared area he has used the brush to form 74 paddocks, and has noted a great improvement to his veld in consequence of the bush clearing and controlled grazing. His paddocks are jackal-proof and, carefully made, the fences will exclude even hares. The tree also makes a "strong rough hedge" according to Sim (1907, p. 213), and its habit of coppicing would make re-establishment easy if the hedge became too open—a dense growth of young shoots is produced if the main stem is chopped off near the ground. The spreading habit of the larger specimens makes them excellent shade trees, and for shelter Acacia parkland is an asset to any farm. Its most important use by far is in providing firewood. By comparison, little else is used in the Border area, and it is interesting that Sim (1907, p. 49) records its complete disappearance from areas of the Transkei where it has been used up for firewood.

Acacias do not impoverish the soil, on the contrary their development of root nodules makes it a safe assumption that they enrich it through the addition of nitrates. Gilbert (1949) is one of the very few who takes this matter into consideration.

When the species gets out of control, the damage it causes outweighs any good it can do. It forms thickets which are for practical purposes impenetrable. Young trees on the Grahamstown commonage may be one to the square yard, and there are patches of larger trees nearly as dense at Keiskammahoek. Areas like this can be entered by stock only with difficulty or not at all, and the ground vegetation consists merely of weedy herbs. Dyer (ms.) has made some observations on the way Acacia inhibits the growth of useful vegetation. Referring to a farm in the Fort Beaufort district, he states:—

"Mr. Malan had a cultivated field 1000 yards long adjoining a grazing camp. Mr. Malan's neighbour had removed the mimosa along the fence for about 100 yards, and, for the remainder, 900 yards of cultivated land was bordered by the mimosa growth 15 feet in height. The first point noticed was that the trees adjacent to the fence had produced the first green shoots of the season, whereas trees 30 feet away showed very little or no sign of green.

On looking at the maize stalks still standing, I noticed that along the fence where Acacia had been removed the maize had flourished right to the margin of the ploughed land, whereas in a strip 30 feet wide adjacent to the Acacia practically no maize growth was to be seen. Mr. Malan stated that the roots of the mimosa penetrated easily to a distance of 30 feet into his field, and that in ploughing roots were constantly removed. This is a striking object-lesson on the detrimental effect of mimosa on the impoverishment of soil for other vegetation."

As has been pointed out, however, this effect is more likely to have been caused by competition for water than by impoverishment of the soil.

There appears to be little hope that eroded areas would ever be healed if they remained under Acacia. The work of Bayer (1933) shows that conditions in such areas become progressively worse. Bad cases are illustrated in the pamphlet by Pentz (1938, photographs 4 and 5), and in *The Farmer's Weekly* (27th July 1949, p. 52). As will be shown later, it is not likely to prove a nuisance in the lower rainfall areas. In criticising Hobson (1896a) for advising the planting of this tree in the Graaff Reinet district, "Anti mimosa" (1896) was judging from his own area, Riebeek East, which has a rainfall of over 20 inches.

DISTRIBUTION AND LIMITING FACTORS

In Africa as a whole, the genus Acacia comprises easily more trees than any other. The area now dominated by it is immense, its relations to grasslands a continental problem of the greatest importance. Rose-Innes, in a personal communication, says:—

"It starts down in the coastal belt, stretches up along the east coast with several excursions into the interior, then it is found on both coasts and goes on north (with the exception of the equatorial forest section)

right to the boundary of the Sahara in the west (I saw lots of it on the coast at Cape Verde), and on into Abyssinia and beyond in the east."

Bews stresses this point in his paper on the succession in the thornveld of Natal (1917a).

Acacia karroo provides a good foundation for study because it is South Africa's most southerly representative of the genus; thus at the limit of its range southward one may begin by watching one species without being confused by the behaviour of a mixture of close allies. In addition, its foothold is likely to be precarious, so that slight changes in the habitat should influence it far more strongly than equal changes further north—for example, where it is barely able to exist in a dry area, a decrease of a few inches in the annual rainfall would probably be fatal. Where there is moisture and to spare this decrease would not be significant. The large number of climatic regions in the eastern Cape and the Cape Midlands is shown in the paper by Schulze (1947)—such conditions yield information more easily than regions with an even climate (Schimper, 1903, p. 451).

Sim (1907, p. 212) states that it is South Africa's most widely-distributed tree, extending from Cape Town northward and eastward. In spite of its tropical affinities, it is not a recent introduction in the southern part of the continent. It has been calculated that a specimen in Parliament House grounds, Cape Town, germinated in about 1572 (Hutchins, 1892, p. 180). Sim also mentions that it extends up to an altitude of 4000 feet from the eastern coast and "considerably further from the west". This last statement, however, is too sweeping, and applies only to the country north of the Orange River, where it is found as far east as the main road from Bloemfontein to Johannesburg, the altitude of which is about 4500 feet. Instances will be given to show that it does not extend so high south of this area. In the Keiskammahoek district the Acacia occurs mainly below 2500 feet, in thickets on the commonage round the town and on the more gentle slopes at Lenye Forest Station, and peters out at about 3500 feet.

Sim (1907, p. 212) writes: "Its range is however curiously affected in places, being absent, possibly through frost, in several large flat alluvial localities where single trees have grown to perfection", and again, of east Pondoland (1900, p. 200), he writes: "The common mimosa is here, as elsewhere, most erratic in its distribution."

But if one disregards these many small irregularities, one finds that its boundaries are fairly clearly defined, and this being so it should be possible to find its limiting factors with reasonable accuracy. In the field it is impossible to deduce with certainty the influence of a particular factor. Acting as a whole, they are so closely linked that a change in any one upsets the balance between them all. Other things being equal, a change for instance in the holard affects soil temperature (Beadle, 1940, p. 184) and aeration (Kramer, 1944, p. 525), a change in air temperature is related to evaporation (Leighly, 1937) and soil temperature (Aitken, 1922, p. 214), and these in their turn act on other factors so that the whole environment is changed. In a general survey one is thus forced to regard mainly those factors strong enough to overwhelm their subsidiary influences. Although there are dissentients and exceptions (Beadle, 1951), it has been generally accepted since Schimper's time that the climate has the greatest influence on plants, and that of the climatic factors moisture and temperature are the most important. Schimper (1903, p. 160) states that the type of *vegetation* is determined by the moisture and the type of *flora* by the temperature—in other words that the rainfall and the presence or absence of desiccation will determine the growth of trees, grass or desert, and that the temperature will determine what particular species are present in each formation—and observations of ecologists in all parts of the world indicate that this concept is sound (see Dansereau, 1951, pp. 193–4).

The main possibilities therefore for its absence from parts of the Cape Province are:—

(*a*) Excess moisture;

(*b*) dryness;

(*c*) low temperatures;

(*d*) high temperatures.

To these possibilities the following arguments may be applied:—

A. Absence Caused By Excess Moisture

For

1. Acacia is found at Queenstown where the annual rainfall is 20 inches (Irrigation Department *Rainfall Map*, 1939), and is absent from 24 miles north of Queenstown to Aliwal North and beyond, where the rainfall is from 20 to 25 inches.

Against

1. It grows freely on the road from Port St. Johns to Lusikisiki, which is above the 45-inch isohyet and has a humid climate (Schulze, 1947).

2. Trees thrive at the intakes to dams and in the seepage areas below them.

Conclusions

It is not limited by excess moisture, as far as 45 inches of rain at least.

B. Absence Caused By Dryness

For

1. Although absent from the veld generally, in karroid areas it will grow in depressions and watercourses where additional moisture collects. This fact was noticed by the earliest travellers as the following passage from Barrow shows (Barrow, 1806, Vol. 1, p. 48). Of the country about 15 miles north of the Swartberg, that is 30 or 40 miles north of where Calitzdorp is to-day, he writes:—

> "Though the surrounding country was destitute of vegetation, a thick forest of mimosas covered the banks of the Dwyka, and followed it through all its windings. This plant grows indeed on every part of the desert, of which it is the inseparable companion of all the rivers and all the periodical streamlets."

The region mentioned has a rainfall of under 5 inches. This relationship, mentioned also by Schimper (1903, p. 630), may be seen to-day in any watercourse of the Great Karroo or the Fish River Valley.

2. Towards the 15-inch isohyet it will grow also along the margins of the roads. Counts have been made near Fort Brown on the road between Grahamstown and Fort Beaufort (see Table 15), and the scattered fringing trees are a feature of parts of the road between Pearston and Graaff Reinet. The rainfall is between 10 and 15 inches in both areas. A possible explanation of this is that the slight run-off from the hard and cambered road finds its way to the edges, and there provides the extra moisture needed for the establishment of the seedlings.

Because Acacia is absent from the roadsides in the area mentioned by Barrow (as is noticeable along the national road between Laingsburg and Prince Albert Road) one may assume that towards the 5-inch isohyet the extra moisture provided from even macadamised roads is not enough to support it.

3. With increasing rainfall it is able to move out from the favourable areas and invade others, less favourable, in the vicinity. Its place along the stream banks is then taken over more and more by different trees, very commonly *Combretum salicifolium* and *Salix capensis* in that order. The riverine vegetation is a reliable indicator of conditions in the sur-

Table 15

INCIDENCE OF *ACACIA KARROO* IN DISTURBED AND UNDISTURBED VELD, FORT BROWN

Belt Transect Figures, in Sections of 12×12 yds.

Margin of Road (Disturbed)	*Adjoining Veld (Undisturbed)*
7	0
1	0
1	0
4	2
5	2
1	3
2	3
4	2
5	2
2	0
2	2
9	2
6	0
4	1
1	1
1	2
3	2
1	1
3	0
6	1
3	3
6	6
5	1
6	2
7	0
5	0
3	1
8	2
4	0
1	0
1	0
0	0
6	2
9	3
8	0
2	0
2	0
1	0
1	0
0	1
0	0
2	1
10	1
6	0
1	0
6	0
8	0
25	0
7	0
9	1
2	2
8	0
17	0
1	3
2	2
7	1
5	1
2	0
5	3
2	0
1	0
1	0
4	1
7	6
284	69

rounding country, and can often provide a clue when these conditions have been masked by overstocking. The change from Acacia to Combretum and Salix takes place in a rainfall of between 15 and 20 inches. Below this point the country is the Karroid Veld of the eastern Cape (Acocks, in press), and in such areas grass pastures are maintained with a certain amount of difficulty and overgrazing tends to bring in not pioneer grasses but karroo bushes (Dyer, 1937, p. 87). Above this point Themeda pastures or mixed scrub of a more mesophytic character is the rule. Here the grass cover is more easily maintained in some form or another and karroo bushes make their appearance only after prolonged overgrazing. An example of this is to be seen on the road from Grahamstown to Bedford about 12 miles north of Carlisle Bridge where there is a fork for Adelaide in country which is now covered with karroo bush, and has its gullies fringed with Acacia. The change to moister conditions, where karroo bush is absent, and where Acacia can grow away from the gullies, is clearly visible 9 miles from the fork on the way to Adelaide.

It may be legitimately asked why Acacia, which can stand 45 inches of rain in a humid climate, does not continue along the streams even where it is able to exist away from them. The reason is that improved water supplies make it possible for the more mesophytic and broader-leafed trees to establish themselves, and the effect of their deeper shade is unfavourable to the growth of Acacia. If for any reason the invasion by shade trees is delayed or prevented, the Acacia remains, and this may be seen along the Jukskei River north of Johannesburg, where the rainfall is 25 inches. Acacia trees in the deep shade of forest margins are barely able to live in a weakened and divaricate form, as is shown in parts of the Lenye Forest Station, Keiskammahoek, and they are "always absent from high forest" (Sim, 1907, p. 4). This fact is supported by the observations of Bews (1917a, p. 157).

An interesting fact is that Acacia is absent from the whole of the Knysna region with the exception of two small isolated patches (Phillips, 1931, pp. 142, 162), and it is a strong probability that shade is the force responsible for excluding it so effectually from this area of climax high forest—not only the largest in the Union but one extending formerly over a much wider area (Phillips, 1931, p. 233).

4. Acacia growing in damp situations develops into a fine shady tree with a clean bole and few thorns, but on shallow soil, especially in exposed places, and in dry situations, it becomes a gnarled bush, branching, thorny and stunted. Such trees remain so permanently, and can not be regarded as merely juvenile forms which, having lately invaded the area, are still to grow. If this were so, one would expect to find at least some large trees under dry conditions, but this is never so. Additional evidence is given by photographs taken in 1912 or thereabout by Mr. W. M. Spring, showing the drier parts of the Keiskammahoek commonage with the small trees described—an examination of the same area in 1949 established that for the trees as a whole there had been no perceptible increase in size during the past 37 years. The response to moisture was noticed by Lichtenstein round a spring known as the Hofmansgat, near Assegai Bush, between 1803 and 1806. Concerning the mimosa, he writes:—

"In the karroo these trees have the form only of large shrubs, branches coming up from the very roots, which are fast enclosed in the earth: here they have stems 8 or 10 feet high before any branches are thrown out."

Against

There appear to be no valid arguments against this theory.

Conclusions

These data show that there is with decreasing rainfall a limit beyond which the species cannot normally exist, and that it may be expected to disappear from the landscape in general between the 20-inch and the 15-inch isohyets.

Absence Caused By Low Temperatures

For

1. Acacia trees cease at the following clearly-defined points, although they are common from these points into regions of lower altitude:—

(*a*) Main road between Bedford and Tarkastad, south of de Beer's Pass at Cheviot Fells, altitude 4500 feet;
(*b*) 7 miles from Toise River on Henderson road, altitude 3500 feet;
(*c*) 7 miles from Cathcart on Henderson road, altitude 3500 feet;
(*d*) 3 miles from Cathcart on Queenstown road, altitude 3500 feet;
(*e*) 7 miles from Happy Valley on Cathcart road, altitude 4000 feet;
(*f*) Post Retief Post Office, altitude 4000 feet;
(*g*) main road between Adelaide and Tarkastad, 4 miles north of fork to Glenthorn, altitude 4000 feet.

As it has been established that the temperature drops with increasing altitude (Sim, 1907, p. 38; Schimper, 1903, p. 701), it is possible that its spread is stopped beyond these points by the greater cold. It may be argued that it is still on the move and may yet cross these limits, but the facts which follow militate against this possibility. Firstly, the altitude is fairly uniform. Secondly, Pringle (1825, p. 34) reported of the headwaters of the Baviaans River: "We found the valley sprinkled over, as has already been noticed, except at the extremities of its subsidiary cleughs, with fine clumps and groves of mimosa trees, interspersed with open grassy pastures . . ." Cheviot Fells (see paragraph 1a) is in this immediate vicinity, which means that the altitudinal boundary was substantially the same 120 years ago.

2. Clements (1934, p. 48) has shown that under conditions of drought the mesophytic trees drop out in order on the following aspects:—

south-west
south
south-east
north-east.

In other words, these aspects have in order less extreme conditions. In the southern hemisphere the corresponding aspects are:—

north-west
north
north-east
south-east.

These deductions are naturally not to be taken at their face value, for conditions may be different in the eastern Cape because of localised conditions like rain shadows and the nearness of the sea. Field observations, however, have shown that they do hold true. A good example is to be found on Round Hill (see page 104). It is a regularly-shaped hill and isolated. Its southern slopes support mixed bush, including such genera as Pittosporum, Pterocelastrus, Pleurostylia and Cassine, and it will be shown later that this bush is more mesophytic than the clumps of Acacia which are the only trees on the slopes facing north (see photographs 4 and 5). In addition, these are stunted by comparison with the few individuals found on the south side where clear spaces provide the sunlight necessary for them to grow. The more detailed relationships of climate and aspect may be inferred from the meteorological observations from the

Keiskammahoek district. At all five stations the temperatures were found to increase through the morning to their maximum round 2 p.m. (see Figure 3), thus it is the north-west slopes which receive the direct sunshine during the hottest part of the day, the north-east ones receiving it when the temperature is mild, with the north slopes intermediate.

These observations, and the work of Aitken (1922) and Potzger (1939) indicate why it is that towards its altitudinal limits Acacia drops out on the south-facing slopes first—they are the colder ones and are therefore less favourable to it. So far no exceptions have been found to this rule. The difference between its limits on south and north slopes can be seen without difficulty for it amounts to several hundred feet. Good examples occur at points (*a*) and (*g*) tabulated on page 35.

3. Twenty-four miles from Queenstown on the road to Aliwal North the slopes face east and west, and, as might be expected, the trees drop out first on the east-facing slopes.

4. Temperature data for the Union as a whole on a more general basis are given in the bulletin published by the Meteorological Office (1942) and printed by the Government Printer, Pretoria. Acacia is absent from a large area of the Union, corresponding closely to the region of mean absolute minimum temperature for July of 20°F and below, and shown in Figure 4. The data in this bulletin, with minor differences according to the way in which they are expressed, agree in showing this region to be the coldest in the country. As Schimper (1903, p. 417) has shown, an *exact* correlation between temperature and vegetation is impossible, but the *general* correspondence in this case is striking, particularly in the example given. The minimum is chosen for an illustration because it is the extremes of factors which have the main influence on the vegetation rather than the average (Cox, 1933, p. 316; Balchin and Pye, 1950, pp. 345, 347). An example from Kendrew (1922) clearly illustrates how the two may differ: Pekin and the Scilly Islands have almost the same mean temperature, yet the monthly means range respectively from 79° to 23° and 61° to 43°.

Against

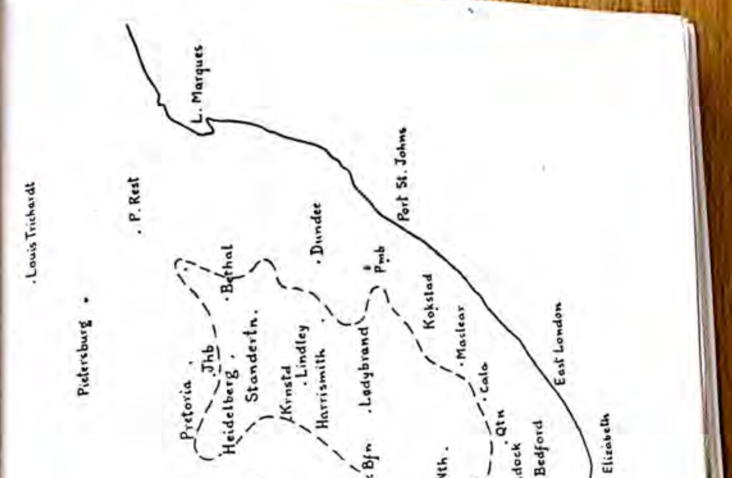
1. Acacia is able to exist even where snowfalls are experienced. They occur at Queenstown, which is notorious for its Acacia encroachment, and Acacia trees have been seen under snow near Indwe. However, the presence of snow does not necessarily indicate an extremely cold area even if judged by South African standards. Both the examples given lie outside the cold region shown in Figure 4, and the objection therefore does not appear to be a serious one.

2. Many authors, Sim (1907), Bews (1917b) and Schelpe (1946) among those in South Africa, have discussed the drop in temperature which goes with increasing altitude. The drop is apparent from the fact that mountains sufficiently high will reach the line of perpetual snow, wherever they may be situated. Most authors mention also that during the night the cold dense air on the mountain tops sinks down into the valleys, and that warmer air may take its place. If this happens, the normal relation of temperature and altitude is reversed, a state of affairs known as "temperature inversion". From this they conclude that the heaviest frosts at night will be in the valleys, and confirmation is to be found in papers by the Meteorological Office (1942) and by Whitmore (1949a).

The Meteorological Office pamphlet, Chapter 5, p. 7, states:—

"It is common knowledge that frost occurs more readily and more heavily at the lowest point of a valley than on the slopes (especially on the northern side) of a range of hills or mountains."

With respect to frost-free areas, Whitmore recommends the upper



UNION OF S.A. (From Div. Met. Publication Temperature, 1942). Showing zone of mean abs. min. temp. for July of 20° F and under.

Fig. 4

and middle slopes of hills as being the safest. In all these papers, however, there is an awkward lack of comment on a difficulty which arises with respect to a *high* mountain. Kilimanjaro may be chosen as an example for the purpose of illustration. The top is well above the perpetual snow line and the base is frost-free, but the papers cited, taken at face value, would lead one logically to the wrong conclusion that there would be heavier night frosts at the foot than above the snow line.

The following is an extract from a letter which was written in this connection to the Director of the Division of Meteorology:—

> "I should be glad of your comments on the following aspects of temperature. The general rule is that temperature decreases with altitude. At night, however, the heights cool more rapidly than the valleys, and the resulting high cold air drains downwards so that the heaviest frosts occur in the lowest parts—this you have explained in your pamphlet on temperature. Yet I feel that this is not the whole story, as the highest mountains experience the most severe frosts. Postulating an ideal mountain slope (that is, without irregularities), could one expect to find on it a point which would be warmer at night than both the top and the base? The absolute minimum temperatures are important from the vegetational point of view. Regarding them, is there some general rule by which one may know for any particular place which of the two contradictory factors—cold air drainage and altitude—is the determining one?"

I am indebted to the Director for the following reply:—

> "In reply to your Minute M 19 of the 27th ultimo I wish to point out that the general rule that air temperature decreases with altitude applies to the free atmosphere. The presence of a land mass, whether with an ideal slope or not, complicates matters to such an extent that no simple rules can be derived for the variation of night temperature with altitude at the surface of a mountain slope."

Although the presence at night of a warmer zone sandwiched between two colder ones cannot be predicted with certainty, there is some evidence for its existence, for Sim (1926, p. 494) refers to:—

> ". . . a native's frost-free garden at about 7000 or 8000 feet altitude, while the river was frozen over in the valley below, and snow was on the berg above."

To sum up, mountains are in general cooler than the lowlands, but because of the complicating influence of cold air drainage and because of a possible warm zone somewhere on the slopes, the evidence given in paragraph 1 cannot be regarded as entirely conclusive.

D. Absence Caused By High Temperatures

For

1. Burtt Davy and Hoyle (1936) do not record *Acacia karroo* from Tanganyika or Kenya, which, being in the tropics, are in general hotter than southern Africa.

Against

1. It grows in the low country of the eastern border of the Kruger National Park, which the temperature map shows to be the hottest part of the Union.

2. Marloth (1925) mentions its occurrence as far north as "southern tropical Africa". This agrees with the publications of Baker (1926) and Burtt Davy and Hoyle (1936), both of which record it from Nyasaland.

Conclusions

There is a possibility that the high temperatures of the equatorial regions are unfavourable to it, but heat does not limit its distribution in South Africa.

General Conclusions

The evidence is that dryness and cold each limit its spread, but that it can stand a great deal of heat. Sim's observations (1907, p. 212) are in support of this:—

> "Although usually evergreen, yet in dry cold carroid localities it is often leafless for years in succession, and is then enormously spiny and colours the veld white instead of green."

Spininess and the shedding of leaves are reactions to dryness (Rawitscher, 1948, p. 258; Schimper, 1903, p. 17); their presence as described by Sim is an abnormal feature of this tree, and shows that it is out of its true habitat.

Bews (1917b, p. 542) suggests that Acacias are absent from the greater altitudes because of the lack of lime in the soil, and common in the valleys where it is plentiful. That this is more likely to be a reaction to temperature is indicated by the Acacia thickets in some of the country lying about 15 miles north of Johannesburg, notwithstanding the fact that the soil is derived from granite and is accordingly highly acid, with pH values of about 5·5 (Meredith, 1947, p. 73). Potts and Tidmarsh (1937, p. 74) have also observed communities of Acacia growing in a soil which continued to show an acid reaction down to 3 feet. A second point is that *Acacia karroo*, although present in abundance in alluvial soil in the Riversdale district, is absent from limestone ridges (Muir, 1929, pp. 31, 37). Probably therefore the pH of the soil is a matter of indifference to it. Observations show that it is undiscriminating as to soils. Although Muir (1929, p. 33) reports that it is not found on the sand-veld of the Riversdale district, it has been noticed growing well on sand 20 miles from Hoopstad on the Bothaville road and (together with mixed scrub) round the town of Bothaville itself. Its absence from the Standerton district might argue that the heavy turf soils of that part are unfavourable to it, were it not for its healthy growth in the black turf of the Springbok Flats. It can grow on the deepest alluvial soils (Muir, 1929, p. 37) and on shallow soils overlying the bed rock.

NATURAL ENEMIES

Confirmation from many sources can be found for Sim's statement (1907, p. 212) that it is the host of "an innumerable lot of pests". In the Keiskammahoek area it is attacked by a bagworm, probably the wattle bagworm, reported as a parasite on this tree by Henkel (1932). Another important parasite which has been noticed here and there is *Prosopophora prosopidis* var. *mimosae*, a scale insect causing great destruction to the Acacia at certain times, but having peak periods alternating with others during which it dies out through some unknown cause. E.W. (1896) writes as follows:—

> "About twenty years ago this scale visited the Kowie valley, between Bedford and Adelaide, entirely destroying the thorn trees in the course of two years. It then disappeared altogether until last year, when it made its appearance again and now the same glorious work of destruction is going on."

The insect has been studied by Lounsbury (1896 and 1898), who states that it may be encouraged to invade areas by tying infected twigs to healthy trees towards the end of December, which is the time the eggs are laid. The newly-hatched insects make their way off the infected twigs and distribute themselves over the tree, but it is only the youngest stages which can move about, and it is consequently useless to try this method at any other season.

Besides the destruction of green pods by the Longicorn and Lamellicorn beetles, there is destruction of the ripe seeds by *Nariscus cinctiventris*, which is described by Stal (1864). The insect is common near the Acacia trees and may be seen attacking the seeds on the ground by puncturing them with its proboscis. This is hairlike, flexible and half an inch long, but nevertheless goes through the extremely hard testa, and the insect may be lifted up with the seed hanging from the mouth parts. By far the most important destroyers of seed, however, are the weevils, the species concerned probably being *Bruchus rufulus*. These insects lay their eggs on the seeds after the pods have split open, and the larvae as they feed will readily destroy an embryo lying in their path (Skaife, 1926, p. 579). A study of infestation in Acacia seeds gave the results shown in Table 16.

Germination is very poor in infested seed—8 per cent—while normal germination may be as high as 95 per cent. Normally, infested seeds produce only one insect each, but very rarely two insects may emerge from a single seed. Some other species also have this peculiarity, for example *Bruchus pisorum*, and the reason for the early death of all but one in each seed is not yet understood (Brain, 1929). Among other insects noticed emerging from the seeds were tiny wasps (Chalcids), which were comparatively scarce. Their larvae were not parasitic upon the weevil as one might suppose, but were also vegetarian. As the seeds from which they are hatched show a slightly higher germination (24 per cent), these wasps are probably too small to do as much damage to the seeds as the weevil. They may attack the green seeds while they are still in the pod, in which case they give rise to galls on the seeds.

There are many other parasites of varying importance which have not yet been studied.

PROPAGATION

FLOWERING AND SEEDING

There is a great variation in the gross yield of flowers from year to year in any one area, and the yield of individual trees is also irregular. The flowers are borne on the periphery of the trees, which begin coming into bloom when about 3 feet high. Although a few flowers may be found in October, the time of their abundance is from February to April and varies with the weather. Flowering may continue in a small way for several months on one tree, until flowers and the same season's ripe seed occur on it together. Occasional trees will bear out-of-season flowers even in the middle of winter, and these will produce seeds if the weather is mild. The mortality from insects, mainly Longicorn and Lamellicorn, is often high, and a dry hot spell may destroy most of the yield and cause a heavy fall of shrivelled brown flowers below the trees. There are about 70 flowers to a head, and from counts done in 1948 it was established that about 1,120,000 flowers (16,000 heads) gave rise to 3200 pods—a flowering efficiency in these particular examples at least of 0·3 per cent. The average number of seeds to a pod was 6·70. One of the larger trees examined (which appeared to be bearing a normal crop) produced 2800 pods; its seeds were probably in the neighbourhood of 19,000. Seeds from different localities vary greatly in colour and size—there may be from 560 to 1030 to the ounce.

The pods, from one to seventeen to a peduncle, are curved and vary in length between 1 and 2 inches. They are slightly constricted between each seed, which thus lies in a compartment of its own. Usually they dehisce down their length when ripe without falling from the peduncle and without shedding their seeds. Alternate seeds are attached to the same half of the pod, and to its inner curve, by a quarter-inch curly funicle. The hilum faces away from the pedicel. Although both Marloth (1925, Vol. 2, Section 1, Plate 18) and Sim (1907, Plate 61) show adjacent seeds in the same half of the pod, all the evidence so far seen indicates that their drawings are incorrect regarding this detail. Pods begin forming towards the end of February and are ripe in the middle of May as a general rule, but the ripening is irregular, and pods of different ages may be found even on the same peduncle. Some of the pedicels and funicles

TABLE 16

WEEVIL AND WASP INFESTATION IN ACACIA SEED

Sample No.	Where Collected	When Collected	Total Seeds	Infested 25/9/47	Infested 14/10/47	Infested 12/11/47	Infested 19/2/48	Total Infested	Per Cent
2592	Ft. Beaufort ..	15/6/47	374	7	54	119	5	185	49
2597	Cradock ..	25/6/47	1,160	16	11	41	4	72	6
2598	Bedford ..	25/6/47	1,314	35	4	18	5	62	4
2601	Albany ..	27/6/47	1,473	117	110	74	0	301	20
2623	Uitenhage ..	28/6/47	322	13	2	1	0	16	5
2702	Ft. Beaufort ..	20/7/47	12,499	1,485	460	885	81	2,911	23
2705	Estcourt ..	—/7/47	4,112	257	106	1,588	25	1,976	48
3142	Pretoria ..	26/8/47	2,442	222	0	0	2	224	9

Total: 23,696 seeds, 5747 infested = 24 per cent.

are resistant enough to allow the seeds to remain on the tree until those of the next season are ripe, and winds even of force 7 on the Beaufort scale will dislodge only part of the crop. By these means, a well-distributed fall of seed is obtained instead of a heavy fall at one time.

Since the reproductive cycle is as a rule completed within the first 5 months of the year, it might be expected that good rains during this period would bring on profuse flowering and seeding, but two years' observations indicate that this is not necessarily so. The rainfall from January to May inclusive was 13·17 inches in 1948 and 6·40 inches in 1949. Of the trees examined, the yield was at least twelve times greater in the drier season, as shown in the following table:—

TABLE 17

APPROXIMATE NUMBERS OF FLOWERS AND SEEDS

Tree No.	21st May 1948	31st March 1949
1 ..	139 pods, no flowers	1000 pods, 500 flowers
2 ..	6 ,, ,,	400 ,, 0 ,,
3 ..	8 ,, ,,	500 ,, 0 ,,
4 ..	0 ,, ,,	120 ,, 0 ,,
5 ..	0 ,, ,,	300 ,, 150 ,,
6 ..	11 ,, ,,	0 ,, 0 ,,
7 ..	200 ,, ,,	100 ,, 100 ,,
8 ..	0 ,, ,,	10 ,, 20 ,,
9 ..	0 ,, ,,	500 ,, 50 ,,
10 ..	0 ,, ,,	34 ,, 400 ,,
11 ..	0 ,, ,,	500 ,, 0 ,,
12 ..	0 ,, ,,	34 ,, 400 ,,
13 ..	0 ,, ,,	200 ,, 200 ,,
	364 pods, no flowers	4364 pods, 1820 flowers

It has been noticed also that along the water-courses in the Fish River Valley there is a tendency for the trees to bear more prolifically the further they are from the water-course. A possible explanation is the general one given by Schimper (1903, p. 26):—

"The production of sexual organs is usually impeded by a considerable supply of moisture and favoured by drought."

Phillips also (1931, p. 247), referring to indigenous trees in the Knysna forests, states that strong light, disease, damage, burning—in other words extreme conditions—cause more abundant flowering. Confirmation is to be found in the editorial notes of the *Empire Forestry Review* (March, 1951, p. 15), where it is mentioned that "ill-treatment of fruit trees in making them produce more fruit dates from very ancient times", and that the practice has recently been applied experimentally to forest trees in the United States.

SEED DISPERSAL

Seed dispersal was first investigated on the Grahamstown Commonage East. The area is for practical purposes level, and is covered with a uniform and closely grazed turf of *Themeda triandra*. Apart from scattered individuals, the trees are concentrated into thickets about 20 yards in diameter, with their perimeters fairly clearly defined. As the thickets do not coincide with dips, rises or old disturbed areas which could possibly account for their patchiness, the reason for this peculiar distribution is at first puzzling. Some of these thickets are found with a large tree growing close beside them, a relationship common enough to suggest the possibility that the large tree is the parent. It is never in the centre of the clump but always at the edge and always on the

western edge. This in turn suggests wind dispersal—not from moderate winds, which would hardly be capable of transporting seeds so little adapted to it, and which in addition come from any quarter, but from strong winds. There are no satisfactory data as to their force and direction as Dyer (1937, p. 54) has pointed out, but a clue is given by two lines of telegraph poles running across the area. Except every tenth one, which is anchored, they are all inclined away from the perpendicular in one direction. Having been found by means of a plumb bob for 20 unanchored poles, the direction of greatest slant was measured by compass and gave an average magnetic bearing of 133 degrees. From 12 parent trees the magnetic bearings through the centres of the corresponding patches of seedlings averaged 126 degrees. Details are given in Table 18. It is felt that this very close correlation establishes the direction of the prevailing winds and establishes that these are the main agents of distribution. As they travel at a magnetic bearing of 130 degrees (between 133 and 126) they blow from the back bearing, that is 310 degrees. Corrected to the true bearing, this is 290 degrees, or west-north-west. This supports Dyer's observation that these strong winds are mainly from the north-west.

TABLE 18

DIRECTION OF STRONG WINDS AS SHOWN BY TELEGRAPH POLES

GRAHAMSTOWN COMMONAGE

Pole No.	*Direction of Slant*
1	95
2	140
3	125
4	120
5	131
6	150
7	150
8	137
9	146
10	110
11	134
12	135
13	155
14	128
15	148
16	134
17	145
18	118
19	122
20	141
	2664

Average = 133 degrees magnetic
= 113 degrees true
Back bearing = 113+180 degrees
= 293 degrees
Prevailing strong winds from 293 degrees

GROUPING OF ACACIA SEEDLINGS WITH RESPECT TO PARENT TREE

GRAHAMSTOWN COMMONAGE

Tree No.	*Bearing of Seedlings from Parent Tree*
1	145
2	123
3	125
4	115
5	132
6	115
7	130
8	125
9	129
10	115
11	130
12	130
	1514

Average = 126 magnetic
= 106 true
Back bearing = 106+180 degrees
= 286 degrees
Bearing of parent tree from seedlings 286 degrees

As a further check on wind dispersal, the commonage was visited on the afternoon of 21st June 1949, when the first strong wind of the season had been blowing since the morning. The wind was coming from the true west, the force 7 according to the Beaufort scale, and to leeward of the seeding trees the freshly fallen pods and seeds were numerous, ranging from 8 to 32 to the square yard, with an average of over 20. Some seeds were attached to the open pods, others were still completely enclosed and the rest were free. Even in this strong wind, which was obviously well capable of blowing such things for great distances, the pods were found to be caught up in the short grass close at hand and to correspond very nearly with the area occupied by the seedlings. In all, strong winds on the commonage were checked five times, with the closely similar results given in Table 19.

TABLE 19

DIRECTION OF STRONG WINDS BY OBSERVATION

GRAHAMSTOWN COMMONAGE

Date	*Force*	*Bearing into Wind*
21/6/49	7	290
23/6/49	6	335
11/7/49	7	315
18/7/49	7	330
5/9/49	6	280
		1550

Average = 310 magnetic
= 290 true

Prevailing strong winds from 290 degrees

These facts still do not account for the many patches of young trees which have no parent tree near them, but traces of the parent were found nearly always. Sometimes the stump was still to be seen, sometimes its former position was shown by the presence of a cushion of cropped scrub pioneers like *Scutia myrtina*, *Gymnosporia buxifolia* and *Carissa bispinosa*. At times all that remained was a hollow about 12 feet across. Such hollows are often found round the stems of the large trees and are caused by the trampling of cattle which come together under their shade. It remains long after the tree has vanished (see photographs 6 and 7). It was possible to confirm this by digging down into the centre of the hollow and finding the cortex of the roots still preserved, lining the inner surface of a system of radiating tunnels, the vascular tissues having rotted away, leaving the tunnels clear inside.

Dispersal by water probably takes place only during storms, for the seeds are heavier than water. In the lower parts of the Fish River Valley, where the trees line the watercourses, this is an important means of dispersal as is shown by the many seedlings which come up in the sandy beds. The trees play a useful part in such areas in catching rubbish and checking erosion.

Grazing animals do not transport the seed to any extent in the Grahamstown area. If they did, it would be shown by the presence of seedlings in their droppings but this has never been observed. Although cattle congregate under pines and gums and in natural bush clumps on the commonage, there are no Acacia seedlings under such trees or near them. This fact is probably because there are relatively few seeds produced over the commonage and when the hundreds of established small trees come into bearing and yield plenty of seeds within easy reach of cattle, the results are likely to be very different. Browsing cattle normally do ingest seeds, some at least of which are able to pass through the animal and remain viable. Mr. C. J. Skead, of Gameston, Albany, has been able to collect seed from their droppings, and ten seeds were tested in the laboratory in September 1947. Six germinated at times varying from the fifth to the 117th day. The long period of dormancy of some of these shows that the testa can withstand digestion and yet remain highly impermeable. Seeds germinated in dung in the laboratory to check the possibility that it might be an unsuitable medium for them, established themselves without

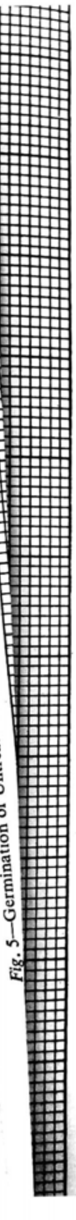


Fig. 5—Germination of Untreated Acacia Seed in Laboratory, 18 Samples of 100 Seeds each.

difficulty. One may infer that most of those eaten will pass through unharmed and will start under ideal conditions.

Seeds of an exotic Acacia were collected by Mr. J. Mullins at the mouth of the Kariega River in January 1948, among the droppings below a dove's nest. These seeds were also viable, and germinated between the 20th and the 87th day. This indicates that doves might also spread *Acacia karroo*, but it has not been possible to find out whether they actually do so.

Germination

(*a*) *In the Laboratory*

The seeds were placed in petri dishes, on filter paper kept moist with rain water, and the tests carried out at room temperature. The mean temperatures during summer and winter were 63 and 59 degrees respectively, and the greatest diurnal range observed was 9 degrees. All seed which appeared to be damaged in any way was discarded, and to protect the sample against fungus a commercial preparation was used. This proved ineffective, but the fungus did not affect the results because the seed germinated in spite of it.

Seeds show the first signs of germination by swelling to about twice their normal size, thus causing the testa to break and peel off in flakes. As a rule the radicle appears first, but occasionally the cotyledons do, in which case there is usually weak growth which soon ceases completely. The seed coat is shed when the radicle is from half to two inches long, and at this stage there is a well-marked frill differentiated on the radicle about half an inch from the cotyledons. When the total length of the seedling is about three inches the lateral roots begin to appear. The leaf at the first node is once pinnate, thereafter the leaves are bipinnate, with the number of pinnules increasing from the base of the plant upwards.

The seeds are unpredictable as to germination time. In the laboratory tests some germinated within a few days while others from the same batch (and thus from the same parent) have lain dormant for more than three years before germinating. The sample with the least germination has in that time produced only nine seedlings from a hundred seeds. The highest figure is 68. Results for the first 29 months are given in Table 20 and Figure 5. All samples still contain apparently sound seed, and germination is continuing. It may be brought about without delay in any sample by making an incision in the seed coat of one of the dormant seeds. Table 20 shows that the germination is comparatively rapid during the first six weeks only, and that besides this proportion of seeds which sprouts quickly there is a reserve of resistant ones which, germinating very irregularly, spreads the risk of an erratic climate and gives some seedlings a chance of striking suitable weather conditions. Similar behaviour has also been noted in *Elytropappus rhinocerotis* by Levyns (1935), who points out the advantage gained, and by Dyer (1935), who, working on *Euphorbia obesa*, found that four out of ten seeds germinated within a week. There were no more until practically a year later, when four more appeared within a few days.

In Elytropappus, the reason for this erratic germination has been proved to lie in the embryo, but the extremely hard testa of *Acacia karroo* suggests that impermeability of the seed coat may be the cause. As a preliminary to the investigations, the seeds were soaked in boiling water, and this greatly hastened germination. Over 100 days, and in an average time of 14·5 days, 63 per cent germination was obtained. A control batch over the same period gave a germination of 21 per cent in an average time of 22·6 days. In this respect, *Acacia karroo* behaves in much the same way as *Acacia mollissima* and *Acacia decurrens*, as shown by the work of J. B. and E. Osborn (1931). In their paper they state that the action of the boiling water is twofold:—

"It appears to be quite evident that the treatment of the seed with

Table 20

GERMINATION OF ACACIA MONTH BY MONTH

MONTHS

Sample No.	Batch No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	Total
3142	1	12	5	0	0	0	0	2	2	0	0	0	1	1	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	1	27
	2	10	1	3	2	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	21
2706	1	5	3	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	1	14
	2	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
2705	1	8	4	3	1	1	0	1	2	1	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	25
	2	10	4	2	3	2	2	0	2	1	1	0	2	0	0	1	2	1	1	0	0	0	0	1	1	1	1	0	0	0	38
2702	1	13	4	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	21
	2	4	3	2	0	2	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	14
2623	1	3	15	13	9	2	4	3	0	0	2	0	1	1	1	1	0	0	0	0	0	1	0	0	0	1	0	0	0	2	59
	2	3	4	11	5	7	12	4	2	1	2	1	1	1	1	0	0	1	1	0	0	0	0	0	0	1	0	1	0	0	59
2601	1	6	7	0	0	1	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	21
	2	8	4	1	3	0	1	0	3	0	0	0	1	0	0	0	0	0	0	2	0	0	1	0	0	0	0	1	0	0	25
2598	1	5	5	2	0	0	0	1	0	2	0	1	0	0	0	0	0	0	0	0	0	1	0	0	2	2	1	1	1	0	24
	2	6	0	0	1	1	3	0	1	0	0	0	0	2	1	0	0	0	1	0	1	1	0	0	0	2	0	2	0	0	22
2597	1	1	14	2	1	0	1	0	1	1	1	0	4	0	3	2	0	1	2	0	3	3	2	2	3	3	3	1	0	0	54
	2	3	4	7	3	1	4	3	1	0	0	2	1	1	0	1	1	5	4	2	0	1	0	0	3	0	0	0	0	2	49
2592	1	17	27	2	1	1	1	1	0	1	0	0	0	2	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	56
	2	18	19	6	5	3	8	1	1	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	1	0	2	0	0	68
		140	123	55	35	21	39	18	15	7	7	7	14	9	7	6	6	10	11	5	5	8	3	4	10	13	5	8	4	10	

Note.—The tests were started in the middle of the first month.

boiling water not only renders the seed coat permeable, but it must also set in action certain physical changes within the seed, which cause seed treated at an earlier date to germinate more rapidly."

This does not appear to be true of *Acacia karroo*, for it has been shown consistently in field and laboratory tests that although the treated samples *as a whole* were quicker to germinate, the first seedlings might be from either treated or untreated samples. In addition, a far quicker and more even germination was obtained by filing through the testa than by treating the seeds with boiling water, and the data in paragraph 2 on page 48 show that germination is not delayed in immature seeds with a green and soft seed-coat. After-ripening is necessary only in the freshest seeds, the process being completed so quickly as to be of little practical significance. The indications therefore are that irregularity of germination is bound up solely with the impermeability of the seed coat.

It has been reported by Phillips (1931, p. 303) that seeds of *Acacia melanoxylon* germinate more readily after scorching. Sim (1907, p. 212) states that this is true also of *Acacia karroo*, the seeds of which germinate better after being "half roasted", and Mr. E. D. Matthews of Tukulu, Alice, reported large numbers of seedlings after a grass fire had passed through a portion of his farm. This effect of fire might be expected from the results of the scalding experiments. To show it experimentally and to find how much the seeds were affected, the following test was carried out:—A four-gallon paraffin tin was cut in half lengthwise, and the halves filled with sand. A sample of 800 sound seeds of *Acacia karroo* was halved, and 400 seeds placed in each tin and covered lightly with sand. Dry grass was heaped six inches deep over one tin and set alight. Both tins were thereafter put in the greenhouse and the sand kept moist. Germination was shown in both tins on the third day by the uneven raised parts on the surface of the sand. The first seedling broke through soon afterwards, and thereafter they appeared rapidly. In the burnt tin many of the testas were charred, and the cotyledons themselves were sometimes scorched and shrivelled through the action of the heat, but there was no bad effect observed on the plants in consequence. Results are given in Figure 6. Germination of the burnt seeds is considerably more rapid at first, but after five months it is overhauled and passed by that of the untreated seeds. Now, 19 months after the experiment was started, the figures are 188 and 245 respectively. Germination is still taking place. The indications from this experiment are that burning will cause a flush of seedlings, but that the final number is likely to be less than would be the case if the seeds remained unburnt, probably because the fire kills part of those it passes over.

The viability is high, as is shown by a test done with four seed samples, varying in age from one month to two years. A hundred seeds from each sample were nicked and germinated at room temperature. None germinated after the eleventh day. Results were as follows:—

1st day	0
2nd day	0
3rd day	271
4th day	62
5th day	5
6th day	1
7th day	9
8th day	0
9th day	0
10th day	0
11th day	6
	354

.. .. 88.5 per cent

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9th day	0
10th day	0
11th day	6
	354

Average germination 88·5 per cent.
Average time 3·4 days

The seeds showed surprising longevity. All those experimented upon were germinated at room temperature and were nicked so that results could be obtained without an unreasonable delay. Results were as follows:—

1. No germination was obtained from seed collected before it had grown to its full size.

2. Pods picked before they had dehisced gave a sample of seed fully formed but swollen and still quite green, and soft enough to be squashed between finger and thumb. Its germination test began the day it was collected. 78 per cent germinated in an average time of 8·8 days. A control batch untreated was germinated at the same time and under similar conditions, and behaved in very much the same way. 82 per cent germinated in an average time of 10·8 days. Germination ceased on the twenty-second and on the twenty-fifth day respectively. The significance of these results is discussed on page 47.

3. Seed was obtained from pods at a slightly later stage but still before they had dehisced. This was soft enough to be cut by the thumb nail but turned the edge of a razor blade. The germination was 89 per cent, in an average time of 5·5 days.

4. When the pods had already dehisced, fresh seed collected from them sprouted normally—95 per cent, average time 4·1 days.

5. Seed 2 years old—97 per cent, average time 3·2 days.

6. Seed 10 years old (E 864 from Estcourt Pasture Research Station, collected on 9th September 1939)—59 per cent, average time 7·8 days.

7. Eight seeds were obtained from a herbarium specimen collected 28 years before at Carlisle Bridge (T. B. Bowker No. 59, May 1921). In spite of the fact that the herbarium specimens are poisoned with mercuric chloride about once every six months, four seeds were viable and germinated in an average time of 3·3 days.

8. Of 5 seeds over 57 years old, also from a herbarium specimen (W. G. Bennie No. 27, Lovedale, 27th January 1891), two were viable. They germinated on the twelfth day, but were lacking in vigour and made slow growth. As the seed-coats became covered in fungus, they were removed from the cotyledons and the plants placed in damp sand. Having continued to weaken in spite of careful treatment, they died, one four and one eight weeks after germination. Three more of these seeds were tested on moss wetted with wettable *Spergon* according to a method used in the Division of Botany and Plant Pathology to guard against fungus attack. All failed to germinate, the cotyledons breaking down to a paste within 3 weeks.

The remarkably long life of the seeds appears to be a generic characteristic. Guppy (1912) quoting Gola (1905) states that legumes in general have highly impermeable seeds and that Acacia seeds are among the most resistant. He also gives an interesting observation by Ewart (1908)—that 60 per cent of Acacia species have seeds which remain viable for more than 15 years. Ewart tested in all 2500 seed samples from various genera and species, and found that less than 1 per cent of them remained viable for this length of time.

It would appear that seeds buried in the ground would not remain viable as long as others stored in the dryness of a herbarium cabinet, because of the fluctuations of temperature and moisture, mechanical abrasion, the work of soil organisms and the like, but Phillips (1926) has shown that the seeds of *Virgilia capensis*, buried over 30 years, were 95 per cent viable. Whether this would be true of *Acacia karroo* cannot at present be established, but the probability cannot be ruled out.

(*b*) *In the Field*

Preliminary tests were carried out in the field in the spring of 1947. Seeds

were planted at a spacing of three inches and roughly half an inch below the surface in holes made with small lengths of fencing wire, the seeds being afterwards lightly covered with soil. The tests were made from a supply of hand-picked mixed seed so that irregularities arising from damaged seed and strain differences might be eliminated, and plots were laid out on level ground at various points in grassland and cultivated ground. No watering was done. Although the possibility cannot be precluded that field germination figures may be affected by chance seeds, every possible precaution was taken against this. The plots were put to windward of seeding trees, and kept free of animal droppings so that the only risk of extra seeds was from those that might have been already buried in the soil. From time to time the plots were visited and the position of each seedling was recorded. In this way a check was kept on all new ones coming up. Some came up unnoticed, and were seen only when established—presumably therefore a few may have died without being seen and thus perfect accuracy cannot be claimed for the field counts. It was feared that newly germinated seedlings might die and disappear without being seen, but the withered remains were found to persist so long that this is unlikely to have been a source of error.

The total germinations over eighteen months were 134 out of 2040 in grassland and 544 out of 4760 under cultivation. These figures work out to 6·6 per cent and 11·4 per cent respectively. This field germination was also erratic, as follows naturally from the laboratory tests, and the last seedlings to germinate up to the present time did so 423 days after the inception of the experiment. Although the germination seems surprisingly low, it is probably the maximum that might be expected in any one season, because there were good rains evenly spread over the summer. From the beginning of October 1947 to the end of March 1948 the total was 16·26 inches.

In the grassland, similar plots were established at the same times as the planted plots and adjacent to them with the one difference that instead of being planted in holes, the seeds were laid on the surfaces of the plots either on the bare ground or in amongst the grasses, as the spacing determined. It was found that displacement by wind and rain was slow, so that most of the seed was in position by the time germination was taking place in the planted plots. The numbers of viable seeds was, however, cut down by the attacks of insects, of which the commonest was *Nariscus cinctiventris*. Germination results up to 8th March 1949 were as follows:—

Plot No.	*Germination*
32	7
33	0
42	0
46	1
50	1
30	10
37	1
41	3
45	1
49	0
	24 out of 1700 or 1·4 per cent.

This low germination for surface sowings tallies with the results given by Cohen (1940). He kept seeds of *Acacia karroo* on the soil surface at air temperature, but there was no germination in 62 days in spite of daily watering.

Germination of the surface sowings at Grahamstown was delayed in the same way as that of the planted plots. The last seedling so far observed germinated in plot 32, and was about three days old on 8th March 1949, 16 months after sowing. Although the total germination is so low, seeds germinated well on wet filter paper in a petri dish set in the sun, from which one may infer that it is the lack of water which inhibits surface germination, and that surface germination is likely to be small, and confined to those seeds which fall in hollows or well shaded places. Good seasons, however, might be expected to bring on a sudden abundance of seedlings.

This may be the explanation of Bayer's observation (1933) that the trees of an Acacia thicket are often of the same size. The same thing is strikingly shown on the Grahamstown commonage to the east of the town. This area has already been referred to, but a repetition of certain points is convenient here: over the area studied (30 acres) there are 29 trees over 6 feet in height, dotted over the flat and standing out conspicuously above a strangely uniform growth of seedlings growing in dense patches between them. These number nearly 4400 and most of them are are about 2 feet in height. On detailed examination one notices many fluctuations over and under the average, looking at them as a whole one cannot but be impressed by their even size. It is not possible, however, to establish within what limits their ages may be the same. Ring counts were tried but the different zones were too obscure to give any results.

There is therefore a certain amount of evidence that trees may not gradually increase in number but that combinations of factors now and again make conditions suitable for sudden increases. The behaviour of *Acacia karroo* in its germination and establishment suggests that the amount and distribution of the rainfall are the limiting factors but it must not be forgotten that there is always a reserve of impermeable seeds which will not germinate with the rest, however good conditions are.

Results from the laboratory experiments on scalding were confirmed by tests in cultivated ground. A sample of seeds was mixed and divided into halves of 2380 each. One lot having been scalded and air-dried, both were planted in the spring of 1947. The scalded seeds germinated a great deal more rapidly and after eight weeks (when the germination of both samples had slowed down to produce the usual sporadic seedlings) a count showed that the figures were 17·3 per cent for the treated and 5·6 per cent for the untreated seeds. The germination of the untreated seeds never caught up with that of the scalded ones, this indicating that the scalding does not damage the seeds as does the burning treatment described on page 47.

The results of all these tests show that any harmless treatment which will make the seed-coat more permeable will very much reduce the germination time. It cannot yet be said that the germination will be higher, for there is no certain means of establishing the final germination figures except where the seeds have had their coats cut through. Scalding is uncertain even if boiling water is used, for the water remains hot for varying times according to the amount so that one can never be sure that all the seeds have been sufficiently treated, or that some have not been damaged by the heat.

Establishment

The seedlings used in the field germination were kept under observation from October 1947 until 1950. Those under cultivation were regularly weeded and the mortality was negligible—only one seedling died out of over 500, as far as is known. In April 1949 they were in perfect health and averaged 17·8 inches in height, with a basal diameter of between a quarter and half an inch. As their continued growth threatened to turn them into a nuisance, they were chopped out in February 1950.

In the grasslands, only 8 remained out of 158 by October 1950, a rate of establishment of 5 per cent. These results indicate that competition from grasses is far too strong to allow the easy establishment of *Acacia karroo* in a dense sward. The plants were too small to warrant measuring. Some of the plots were in protected grassland, and the seedlings grew up in shade. Even here where they were etiolated, the tallest ones were about 4 inches high with thin and delicate stems (see photograph 8). Where there was no shade at all they were stubby and in height only about one and a half inches. It is possible that the loosening of the soil in the cultivated plots may have favoured the seedlings in them. This matter has not yet been investigated.

As the commonage grasses are cropped short all the year round, there is practically no competition for light even at ground level, and it seems that competition for water is a strong factor governing the relationship of grasses to *Acacia karroo*. Murray and Glover (1935) state that Themeda (which is dominant in these areas) uses a great deal of water near the soil surface. It "has a very much branched and shallow root system which extends a considerable distance in a horizontal direction forming a close network a few inches from the surface of the soil". The probability of the decisive part played by competition for water is supported by the lysimeter data of the Agricultural Research Institute, Pretoria, as reported by Theron (undated), who emphasises the amount of water needed by plants and mentions in particular the large requirements of grass, especially where growing actively. The proportion of carbon dioxide in the soil air probably plays a part as well in influencing the relation of grasslands and Acacia (see page 29).

EFFECT OF BROWSING

Sim (1907, p. 212) states that goats are "the surest means of keeping the tree down," but he gives no supporting evidence for this remark.

Dyer (ms.) does not consider goats a satisfactory means of controlling Acacia. Reporting the results of experiments carried out to test the effect of intensive browsing by goats, he writes as follows:—

> "Although none of the mimosa plants have been killed by the grazing their growth has been considerably reduced, and it appears very unlikely that they would ever increase in size while under the grazing of the goats. However, owing to the natural vigour of the mimosa it is doubtful whether this grazing would ever result in the total eradication of mimosa in a reasonably short time. The goat therefore can only be classed as a means of control and its usefulness in this direction will naturally vary according to the veld conditions. Owing to the admittedly destructive nature of goats, I consider that to attempt to control the growth of a large quantity of mimosa in grassveld would be uneconomical and I consider that the mimosa growth should first be removed by other means and later a very limited number of goats allowed on the veld."

Irvine (1941, p. 221) states that goats take grass by preference and that "bulk eradication by goats does not appear to be possible while any grass remains". Mixed stock play practically no part in eradicating Acacia. Of the 96 seedlings under observation on the Grahamstown commonage only three were cropped by animals in spite of the fact that the area is grazed heavily and without rest, and only one of these seedlings died.

It thus seems clear that Acacia is proof against all domestic animals with the doubtful exception of goats, and that it is not harmed by grazing. These observations are in accordance with its thicket formation in heavily grazed areas.

Laboratory tests show that pruning is detrimental only if the plants are cut off near the base. The tests were done on 85 seedlings, grown under cultivation until they were two months old, and on an average one and a half inches tall. With a pair of scissors 42 were cut off flush with the ground. Two recovered from this treatment. The rest were cut a quarter of an inch from the soil surface so that the lowest leaves remained on the stump, and of these all continued growing strongly. More exact tests were then made with younger seedlings.

It was found impossible to get a complete kill at any stage by snipping off parts above the cotyledons; although there was some mortality even the youngest were usually able to withstand amputation as far as the loss of one cotyledon together with the young shoot. Beyond this point they were never able to survive. It seems that no regeneration of the stem can take place below the cotyledons. Contrary to these observations is the following extract from the letter F 6256/R 9201 of 2nd July 1928 from the Chief Conservator of Forests to Mr. S. Rippon, P.O. Highlands Station, Albany, on the eradication of mimosa trees: ". . . there is usually, to a limited extent in grassland, regrowth from root suckers". This may be a mistake, for no supporting evidence has so far been found for regeneration from roots. Scott (1949, p. 40) confirms that Acacia coppices if cut above the junction of root and stem, but not if cut below this point. In trees more than a few years old, however, it is extremely difficult to establish where the junction is situated.

Two pamphlets by Dyer (1930, 1931) give information on the prevention of coppicing by the use of arsenic compounds.

EFFECT OF BURNING

It has been suggested by Wolhuter (1948, p. 121), Phillips (1934, p. 238), Galpin (1926) and Scott (1949, p. 99) that grass fires are important in checking the encroachment of trees, thorn scrub in particular.

The influence of fire was tested on established groups of *Acacia karroo* seedlings which had been grown for the purpose. The plots contained between 40 and 50 seedlings each, and the burning was done on calm days by heaping dried grass over the plants and lighting it. For slow burns, the grass was piled up for 3 inches, for fierce burns 6 inches. The following are the results:—

At 1½ inches, age up to 6 weeks

Slow burn: Although scorched, the seedlings remained green for a day or so before turning brown. All were killed.

Fierce burn: The seedlings were charred and blackened. All were killed.

At 4 inches, age up to 8 weeks

Slow burn: As for 1½ inches.

Fierce burn: As for 1½ inches.

At 14 inches, age up to 12 months

Slow burn: There was little immediate effect visible except the scorching of the lowest leaves. By the next day, however, all the leaves were dead except a few which were on straggly plants, and were thus hanging over the edges of the plot. These also had died within a month. None of the plants themselves were killed, and a month after burning they were making strong growth from the base.

Fierce burn: The effects were similar to those found in the slow burn, but intensified. Six of 40 plants appeared to have died within the first month, but later made a complete recovery, so that there was no mortality. New growth was made in the same way, a feature of this being the death of the original stem and the development of a number of coppice shoots in place of it. Of the burnt plants surviving, 100 individuals gave rise to 346 stems. In the control plots there was only a slight growth of basal shoots, the ratio of individuals to total stems being 100 to 130.

These observations show that there is no hard and fast rule governing the influence of fire on *Acacia karroo*, but that it depends on the size of the plants and on the fire. Scott (1949, p. 99) reports from experiments carried out in Natal that the results of burning are influenced also by the time of the year in which it is done, and states that spring burning is the most effective.

Far from being of value as a means of eradication of well-established scrub,

fire is likely to bring about a thickening of it by encouraging the growth of coppice shoots. It could, however, be used as a means of control when the area had once been cleared of older plants. This is suggested by the experiments described and by the work of Cook (1939), who has demonstrated that a good growth of grass burns with the evolution of very high temperatures. The method could be used firstly to stimulate the germination of dormant seeds and subsequently to kill the resulting seedlings, and could be dispensed with when once the reservoirs of seed had been depleted.

TYPE NO. 2—FORT COX SCRUB

COMPOSITION

This type of scrub, shown in photograph 9, has a rainfall of about 23 inches. Tree growth is short, varying in height from about 7 feet on the stonier parts to about 10 feet on the hills and in the sheltered areas where there is deeper soil. Bushes are spaced in widely differing densities, now aggregated into clumps, now scattered, the spaces being covered in the more protected places with Themeda, Digitaria and Panicum mixed with various shrublets of which the characteristic species are *Lasiocorys capensis*, *Helichrysum rosum* and *Aster muricatus*. Quadrat figures are given in Table 35, page 108.

The absence of the more mesophytic trees gives the scrub a grayish appearance and spiny and thorny plants are common, as is usual in drier localities (Bews, 1927, pp. 67, 75; Phillips, 1931, p. 135). Some stunted specimens of *Buddleja salicifolia* and *Sideroxylon inerme* occur, but these plants are characteristic more of the forests, in which they attain their best development. A few trees appear to be at home equally in the forests and in the scrub. These are *Carissa bispinosa*, *Grewia occidentalis*, *Scutia myrtina* and *Cussonia spicata*. The dry character of the scrub is shown by the presence of individuals of *Euphorbia pentagona* and *Rhigozum obovatum*, and of a few communities of *Portulacaria afra* and *Senecio pyramidatus*. *Olea africana* predominates on the dolerite soils, growing up to twenty feet, as do the widely separated groups of *Euphorbia tetragona*. The general level of all the different tree species, however, is about 10 feet. Visibility where the ground is level is usually over 80 yards.

No epiphytes are present except a thick growth of lichens on nearly all the trees, and the ferns are represented only by a few specimens of the xerophytic *Pellaea hastata*. Lianes are likewise very poorly represented by a little *Secamone frutescens*. There is no Usnea. Phillips (1929, p. 103) has reported that it flourishes in dry and sunny situations, and that it grows poorly or is absent in weak light and under conditions of high humidity, so that "rapid development of the organism under dense forest conditions is entirely impossible". He does not mention that there is a limit to its existence where dry conditions are excessive, but this appears to be so. Although type 2 is too arid for it, it grows well in type 3.

Confined to the banks of the Keiskamma River is a mixture of *Celtis kraussiana*, *Acacia caffra*, *Podocarpus falcatus*, *Combretum salicifolium* and *Salix capensis*, conspicuously higher than the surrounding trees and indicating that this part is well out of the karroid area (see pages 32-4). A very little *Acacia caffra* grows on the hottest and driest parts of the neighbouring hills as well, but this behaviour is out of the ordinary (Sim, 1907, p. 210). There are numerous dry watercourses on the slopes. Their vegetation is not differentiated from that of the surroundings.

EFFECTS OF GRAZING

The trees in general are too small to yield anything useful in the way of timber except wattles for building, and firewood. Their chief economic use is in providing browsing for stock, but woolled sheep are at a disadvantage because of the rough character of the vegetation. Probably the veld would be best utilised by cattle, for the reason that their height enables them to reach most of the tree growth without difficulty. They could be followed by Persian sheep or goats to clean up the more impenetrable parts of the scrub to which the cattle cannot gain access. As will be shown later, this cleaning-up process is essential if the veld is to be maintained in a good state, and sheep and goats can play a valuable part provided that their grazing is strictly controlled. One feels that their bad reputation in respect of ruining veld is perhaps somewhat undeserved, and caused by the fact that their more efficient feeding habits enable them to keep condition so that they are allowed to remain on a particular piece of veld long after they ought to be removed. If the plants are watched as well as the animals the damage need not necessarily occur.

A feature of the tree growth is that it is not deciduous; accordingly the animals have a supply of green food through the winter. In addition the grasses remain reasonably nutritious even when frosted, and stock can be maintained during the dry season, and even fattened, without supplementary feeding.

It is the open grassy spaces which suffer most when overstocking takes place. Between the trees there may be all stages of denudation from areas of bare rock or stony rubble to parts less heavily grazed by reason of protecting thickets, banks or rocks. Mixed with bits of grass is a ragged growth of ruderals like *Gomphrena globosa, Alternanthera repens, Venidium arctotoides* and a little *Chrysocoma tenuifolia*. Cynodon is always present in varying amounts and is the most valuable single plant there is from the point of view of checking erosion. Another equally effective but scarcer is *Setaria neglecta*, which, forming mats several square yards in extent, not only holds the soil but has leaves upright in habit that filter out the sand and coarser soil particles washed across them by floodwater. New growth forms above the silt in the same way as a lawn covers over a top-dressing.

The successionally advanced grasses are seldom quite absent. Scraps of *Themeda triandra* and *Cymbopogon plurinodis* continue growing in clefts and crannies or beneath the densely set twigs of *Phyllanthus verrucosus* or *Randia rudis*, and their astonishing endurance is evident from the way in which isolated and exposed tufts remain alive though leafless even in the hottest and driest localities. They are found in a rainfall as low as about 12 inches in the Fish River Valley, in the form of relicts in the midst of patches of *Euphorbia bothae*. Complete extermination can however occur over fairly wide areas if protection is lacking, and parallel cases are reported by Cottam and Evans (1945) from Utah.

The trees suffer variously according to the animals concerned, for as is generally conceded, sheep and goats do more in the way of browsing than cattle. The intensity of the grazing also has a bearing on this subject. Woody growth is in general passed by where grazing is light and where consequently there is enough fodder provided by the grass, and where this happens trees can and do increase in number. This is shown by the fact that seedling trees become established in the land belonging to Fort Cox Agricultural School and make it necessary for scrub clearing to be carried out at intervals.

With heavy grazing the stock are forced to turn increasingly to the trees for food, and if this goes on indefinitely the species most sought after steadily disappear, as has been reported by Whitlock (1949, p. 59) of *Portulacaria afra*. This damage is, however, insidious, and a careful examination is necessary before it can be recognised, because the woody growth *as a whole* continues to spread under these conditions. Evidence is provided by the establishment of tree seedlings in overgrazed parts, and by photographs 10 and 11 which show this taking place in the closely allied type 3.

TABLE 21

BELT TRANSECT FIGURES

FORT COX SCRUB (TYPE 2)

Area: 4× 608 sq. yds.

Stems Listed: 1 inch diameter breast height and over

Species	Total Stems	Av. Ht.	Av. Diam.	Max. Ht.	Max. Diam.	Per cent Freq.
		Ft.	Ins.	Ft.	Ins.	
Acacia karroo	54	7	1·3	9	2	18·31
Azima tetracantha	30	7·6	1·5	9	2	10·17
Carissa bispinosa	4	6	1	6	1	1·36
Dovyalis zeyheri	1	9	2	9	2	0·34
Ehretia rigida	18	6	1·3	9	2	6·10
Euclea undulata	3	14	5·3	14	8	1·02
Fagara capensis	1	5	1	5	1	0·34
Gymnosporia buxifolia ..	15	8·4	1·5	10	3	5·09
Gymnosporia capitata ..	8	6·5	1·4	8	2	2·71
Gymnosporia polyacantha ..	6	9	1	8	1	2·03
Hippobromus pauciflorus ..	1	10	4	10	4	0·34
Jasminum multipartitum ..	39	14	1	14	2	13·22
Lycium sp.	1	5	1	5	1	0·34
Olea africana	37	8	1·8	14	7	12·54
Pappea capensis	1	1	6	10	6	0·34
Ptaeroxylon obliquum ..	1	13	5	13	5	0·34
Randia rudis	55	6	1	8	2	18·64
Rhus incisa	4	10	1·5	10	3	1·36
Rhus sp.	5	7	2	9	2	1·70
Royena sp.	1	6	2	6	2	0·34
Scutia myrtina	10	9·5	1·8	14	4	3·39
Totals	295					100·02

TABLE 22

ADDITIONAL SPECIES

FORT COX SCRUB (TYPE 2)

Woody plants (*a*) too small to be listed in the transect
or (*b*) noted outside the transect
or (*c*) noted in the same scrub type elsewhere in the district

Acacia caffra
Aloe ferox
Boscia albitrunca
Brachylaena sp.
Buddleja salicifolia
Capparis citrifolia
Cassine crocea
Cussonia spicata
Euphorbia tetragona
Grewia occidentalis
Phyllanthus verrucosus
Plumbago capensis
Putterlickia sp.
Schotia speciosa
Sideroxylon inerme
Tecomaria capensis
Zizyphus mucronata

It is only in times of great scarcity or with exceptionally heavy stocking that the damage to the bushes becomes noticeable. Mr. E. D. Matthews of Tukulu, Alice, has informed me that *Randia rudis* is not eaten on his farm where there is adequate grazing for his stock, but when the animals are desperately short of food they will eat bushes which are normally avoided, as is shown by the photograph of Randia in an overstocked area (photograph 12). As food becomes scarcer they are driven to the extremity of eating the thorny cladodes of Opuntia (photograph 15), and their hunger and the state of their mouths may be imagined. It is reasonable to suppose that these conditions would eventually cause the destruction of trees, and that this can in fact take place is shown by photograph 16 taken in the dry scrub near Wolvefontein.

In the absence of any precise data regarding the rates of stocking only a general statement is possible—that overgrazing in the dry types tends to produce a thickening and a spreading of the scrub, except where the overgrazing becomes devastating in its effects.

EFFECTS OF DROUGHT

It has been noted that the woody growth of type 2 is severely affected by a drought in comparison with the types above it. Towards the end of the 1949 drought the shrivelled and bleached foliage between Fort Cox and Burnshill gave the veld an appearance of having been blighted by frost. *Olea africana* and *Ptaeroxylon obliquum* were very sensitive, being among the first to wither. Even *Randia rudis* lost its leaves although it favours dry localities. Others were *Scutia myrtina, Cassine croceum, Gymnosporia buxifolia, Putterlickia pyracantha* and *Allophylus decipiens*. There were, however, many of these trees which by virtue of some localised compensatory feature kept their foliage among stricken ones of the same species. *Cussonia spicata* was not affected at all, so that the large leaves remained green even under the most severe conditions. This is probably bound up in some way with the moisture content of the roots, of which Sim (1907, p. 230) states:—

"During times of scarcity the Natives dig out the large succulent roots of this tree and live more or less upon them. They have a slightly acidulous taste, and when freshly dug are cool and sappy, and about as easily chewed as a turnip."

TYPE NO. 3—NQHUMEYA SCRUB

COMPOSITION

Type 3 is found on the north-facing hill-slopes from Keiskammahoek more or less to Burnshill, and its general appearance may be seen from photographs 17 and 18. The rainfall is higher than in type 2, neighbouring gauges indicating that it is probably about 26 inches. There is a taller and denser growth of trees, including several which have not been recorded from type 2, and of these the most important are *Canthium ventosum, Chaetacme aristata, Royena lucida* and *Vepris lanceolata*. It is too dry for *Entada natalensis, Burchellia bubalina, Podocarpus* spp., *Rapanea melanophloeos* and *Rhus legati*. The remarks on the vegetation of the streams and watercourses in type 2 apply here as well. Scattered communities of *Euphorbia tetragona* are present. An occasional plant of the epiphytic *Angraecum mystacidii* may be found on the older trees, and ferns, although more numerous, are still the xerophytic ones which grow among the rocks rather than on the ground. Those recorded are *Pellaea viridis, Pellaea hastata* and *Cheilanthes hirta*. Lianes are also commoner, and include *Rhoicissus cuneifolia, Rhoicissus digitata* and *Cissus cirrhosa*. Although the slightly moister conditions are suitable for the growth of Usnea, which

does not grow in type 2, it is the foliose lichens which form the characteristic covering to the stems and branches.

As in type 2, the trees furnish no heavy timber, being useful only for wattles, firewood and fodder. This may be inferred from the belt transects given in Table 31, page 74, which show that the average height is a little over 12 feet and the average diameter a little over 2 inches. The general visibility is in the neighbourhood of 50 yards.

A rather tangled undergrowth about 18 inches in height is made up of a variety of herbaceous plants which together with a sparse growth of grasses combine to form a dense cover, a hindrance to progress and a shelter to numerous rodent runways lying beneath it. The more characteristic plants are members of the *Acanthaceae, Asparagus* spp., *Croton rivularis, Sida triloba, Cluytia pulchella, Barleria obtusa, Abutilon sonneratianum, Plumbago capensis* and *Achyranthes* sp. In the hotter parts the Crassulas become more numerous and there are frequent patches of *Cotyledon orbiculata*.

Thinly wooded areas are common and there is no definite canopy. Glades, prominent on the plateaus and ridges, and with the grasses in them predominating over the shrubs, usually contain scattered Acacia trees. These patches of grass are made up mostly of *Themeda triandra* (which is dominant) and *Digitaria eriantha*. Both of them are common in type 2 as well, but as with the trees, some grasses which have not been recorded in type 2 now make an appearance. They are *Hyparrhenia buchananii, Heteropogon contortus, Eragrostis capensis* and *Setaria sphacelata*.

The birds are substantially the same as those frequenting type 2 and comprise seed-eaters, *Lamprocolius nitens phoenicopterus, Lanius collaris, Clamator serratus* and *Upupa africana*. Although tortoises occur in type 2, they have so far not been seen in the denser vegetation of type 3.

SHALLOW SOILS

On many of these slopes the soil is only 18 inches deep and one finds it surprising that trees are able to exist, particularly when, as it often does, the soil overlies solid rock instead of loose stones or boulders. This structure occurs on the dolerite along Nqhumeya Ridge and is one easily and severely damaged by denudation of the veld (photographs 17, 18). The sheets of stone which eventually become exposed present for colonisation one of the most extreme habitats imaginable, unbearably hot to the touch on a summer day and cold on winter nights, with moisture fleeting and inadequate. The natural reclamation of such places by a new covering of plants and soil is an exceptionally slow process which can be assisted artificially only in a limited way.

The lichens, as one would naturally expect, are the only plants able to exist on a flat rock surface, and by increasingly luxuriant growth they are able to build up slowly conditions better suited to the higher plants (Weaver and Clements, 1929, pp. 61–63). This gradual process is in practice shortened by hollows, cracks and loose stones on the rock surface, which provide soil, moisture and shelter where other plants are able to obtain a foothold. Flakes of rock break down fairly easily into a crumbly gravel, which is also of great assistance to the colonising plants.

Crassula muscosa is one of the first arrivals in the rock crannies, and catches silt and spreads outwards by rooting from its decumbent branches. It is often found associated with *Lampranthus stayneri* which forms dense mats up to 12 inches across. There is however no hard and fast rule governing the sequence or form of the early stages—they include ferns, mosses, liverworts and phanerogams, and differ in their relative proportions from place to place. The commonest are *Cheilanthes hirta, Anacampseros* sp., *Hyophila zeyheri, Bryum argenteum* and *Riccia* sp. Rather unexpectedly, the grasses are sometimes preceded by the sedges *Mariscus capensis* and *Cyperus teneriffae*, which are capable of living as soon as a little thin soil has formed, then soon afterwards *Microchloa caffra*, *Aristida bipartita* and *Cynodon dactylon* begin to appear, roughly in that order. They are mingled at first with an assortment of non-grasses so varied that a complete list would be little else than confusing, but one of these early arrivals is frequent and important enough to be conspicuous above the rest. This is *Falkia repens*, a prostrate matted herb which spreads over bare soil and binds it with a network of branching runners. It is widespread in all the drier localities where its very short growth protects it from the grazing which often destroys plants more upright in habit. Interesting points in connection with its reproductive cycle are that the pedicel curves downwards when flowering is over, bringing the ripe fruit in contact with the ground, and that the persistent calyx, having leaf-like sepals, shelters the seeds from the direct sunshine, and swells with rain to hold them in a soggy pocket. These facts doubtless enable germination to take place where the seeds would otherwise perish and they contribute towards making this plant an outstanding help in reclaiming eroded areas.

Earthworms are active even in the earliest stages of soil formation, their winding burrows when the earth is moist clearly showing that they venture out from the surrounding deeper ground and begin their work of breaking down the vegetable litter even when the soil is barely thick enough to cover them.

As the surrounding soil which borders on these sheets of rock often abuts upon them in the form of a perpendicular face, stock can cause rapid damage around the margins by breaking off portions of it piecemeal. The profile also lays itself open to severe erosion by flood water which runs down the earth walls in the form of small cascades and cuts the soil away. It is self-evident that revegetation and the formation of soil may be assisted by keeping stock away and by diverting the floodwater across areas better covered. Further aid may be given by packing lines of stones across the surface of the rock to provide shelter for the early successional stages and to slow down the speed of the water, after the plan adopted by Pentz in the reclamation of dongas in the Drakensberg Conservation Area. The slowness of soil formation on rock, however, makes it clear that such reclamation works must be looked upon as permanencies. There can be no hope that a single lifetime would be enough to allow these rock slopes to revert to pasture.

That the bed rock has been recently exposed is clearly shown by the small islands of earth remaining here and there upon it, by the clear and sharp transition between it and the soil at its edges, and by the fact that it is well below the level of this surrounding soil. A few of the rock faces show none of these features and thus indicate that they have been exposed possibly for many centuries. They usually take the form of the isolated hillocks shown in photograph 19.

If the eroded areas are where there is deeper ground, or where the soil overlies a rubble of stones and loose rock as shown in photograph 20, recovery is by comparison a quick matter. Even on badly denuded areas the early stage of cryptogams is usually wanting so that the succession starts at a higher level. In the open, *Falkia repens*, the pioneer grasses and mixed non-grasses are the earliest arrivals, mainly because their seeds are easily transported, as in the *Aristida* spp., or because scattered parent plants are present, as with *Cynodon dactylon* and *Falkia repens*, which are widespread and common and seldom completely exterminated by heavy grazing. If the establishment of *Themeda triandra* is delayed it is not because of an unsuitable environment but simply because continued trampling and grazing have destroyed it so completely that parent plants and seed are no longer available when the area is finally rested. Once a few relict plants have made new growth and set seed, its spread is rapid.

In wooded areas the grasses figure in the succession only to a small degree and a mixed undergrowth is built up. The stages have not been examined in detail.

EFFECTS OF GRAZING

One is forced to use loose terms when referring to the rate of stocking because it is uncontrolled and fluctuates enormously. The best that can be done is to state that unless very heavy indeed, the effect of grazing is to give rise to an increase in the area and density of the woody growth in the same way as has been described for type 2. In this respect the behaviour of the two types is closely similar.

TABLE 23.

BELT TRANSECT FIGURES

NQHUMEYA SCRUB (TYPE 3)

Area: 4 × 608 sq. yds.

Stems Listed: 1 inch diameter breast height and over.

Species	Total Stems	Av. Ht.	Av. Diam.	Max. Ht.	Max. Diam.	Per cent Freq.
		Ft.	Ins.	Ft.	Ins.	
Acacia karroo	2	10	1	10	2	0·29
Allophylus decipiens	43	11·8	1·5	24	3	6·30
Apodytes dimidiata	20	12·2	2·2	20	6	2·93
Brachylaena sp.	5	15·2	3·6	18	4	0·73
Buddleja salicifolia	1	23	3	23	3	0·14
Canthium ciliatum	3	8	1	8	1	0·44
Canthium mundtianum ..	2	12·5	1·5	15	5	0·29
Canthium obovatum	21	15·9	2·7	24	5	3·07
Canthium ventosum	2	9	1	12	1	0·29
Capparis citrifolia	13	12·1	1·9	20	3	1·90
Cassine sp.	55	14·8	2·9	24	12	8·05
Commiphora caryaefolia ..	2	10·5	2	15	2	0·29
Cussonia spicata	15	21·1	8·7	25	24	2·20
Dovyalis zeyheri	35	9·9	1·5	18	4	5·12
Ehretia rigida	17	10·7	1·4	16	2	2·49
Fagara capensis	22	12·4	2	19	5	3·22
Grewia occidentalis	58	12·6	1·3	18	2	8·49
Gymnosporia buxifolia ..	45	10·4	1·7	18	3	6·59
Gymnosporia undata ..	1	9	1	9	1	0·14
Hippobromus pauciflorus ..	40	14·7	1·8	25	4	5·86
Jasminum angulare	5	12·8	1	14	1	0·73
Jasminum multipartitum ..	1	8	1	8	1	0·14
Maerua racemulosa	1	9	1	9	1	0·14
Olea africana	50	13·2	3·8	24	12	7·32
Pappea capensis	1	9	1	9	1	0·14
Pleurostylia capensis ..	2	18·5	6	24	10	0·29
Ptaeroxylon obliquum ..	27	14·2	2·7	24	12	3·95
Putterlickia sp.	16	8·3	1	12	1	2·34
Randia rudis	11	7·6	1·2	9	2	1·61
Rhoicissus cuneifolia ..	6	18·7	1·2	25	2	0·88
Rhus longispina	1	14	2	14	2	0·14
Rhus refracta	6	13·7	2	18	3	0·88
Royena lucida	7	9·7	1·4	18	3	1·02
Royena sp.	32	13·8	2	18	2	4·68
Scolopia zeyheri	27	10·4	2	14	3	3·95
Scutia myrtina	27	10·4	1·2	18	6	3·95
Senecio brachypodus ..	4	13	1·3	15	1	0·59
Sideroxylon inerme	3	10·7	5·7	12	6	0·44
Tecomaria capensis	8	11·2	1	14	1	1·17
Trimeria trinervis	30	10·1	1·9	18	4	4·39
Vepris lanceolata	10	11·7	1·8	18	6	1·46
Zizyphus mucronata	6	10·3	1	12	1	0·88
Totals	683					99·92

TABLE 24

ADDITIONAL SPECIES

NQHUMEYA SCRUB (TYPE 3)

Woody plants (*a*) too small to be listed in the transect
or (*b*) noted outside the transect
or (*c*) noted in the same scrub type elsewhere in the district.

Azima tetracantha
Buddleja dysophylla
Calpurnia sylvatica
Capparis rudatisii
Carissa bispinosa
Chaetacme aristata
Cissus cirrhosa
Clausena inaequalis
Heeria mucronata
Ochna atropurpurea
Pavetta capensis
Plumbago capensis
Polygala myrtifolia
Royena villosa
Schotia latifolia
Secamone alpini
Secamone frutescens

TYPE NO. 4—ZANYOKWE BUSH

The tall type of bush growing mainly on the south-facing slopes between Keiskammahoek and Burnshill, and shown in photograph 19, has been classified as type 4. It probably owes its increased density and height over type 3 to the moister and cooler air from the sea and to the fact that it faces away from the sun. The matter has been discussed by Aitken (1922), Phillips (1931, p. 130) and Potzger (1939). Below the trees the light is noticeably dim, for a definite canopy is seen here for the first time, between 20 and 25 feet above ground level. This is not to be confused with the average height, which because of the large number of smaller trees beneath the canopy is just under 16 feet.

The general appearance is rendered a darker green by the increased numbers of broader-leafed trees, among which are several foreign to the two drier types. The list is given in Tables 25 and 26. Tree Euphorbias occur in the form of small and rare communities towards the margin of the bush only, and an easily recognisable plant appears—*Encephalartos altensteinii*. The exotic Opuntias which occur throughout the two drier types are not able to exist in type 4. The few exceptions form elongated and almost terete cladodes and do not branch, and afterwards fall over under their own weight.

The kloofs are dry except immediately after rain, and their vegetation is not differentiated from the surrounding vegetation.

Most of the trees support a dense growth of Usnea and other lichens, and besides the xerophytic *Angraecum mystacidii* and *Polystachya ottoniana*, a xerophytic fern is found here and there as an epiphyte. This is *Polypodium polypodioides*, which under conditions of drought shrivels into wisps of dead-looking tissue and unfolds to become green and fresh again when the rains come. Together with these two are cushions of moss on the tree trunks and on the stones, and a sprinkling of more mesophytic ferns, which include epiphytes and ground ferns, is able to exist. Common ones are *Mohria caffrorum*,

Asplenium bipinnatum, and *Polystichum adiantiforme*. *Streptocarpus rexii* is usually absent. The presence of *Polypodium polypodioides* in type 4 indicates that the evaporating power of the air is less here than in types 1 to 3, where this fern is absent (Pessin, 1925, p. 28).

The number of lianes is increased by the occurrence (although as a rarity) of *Entada natalensis* and by two more species of Rhoicissus—*Rhoicissus digitata* and *Rhoicissus rhomboidea*—, and there are three plants which turn here into definite climbers after appearing as bushes or at most weak scramblers in types 2 and 3. These are *Scutia myrtina*, *Azima tetracantha* and *Royena* sp. *Ptaeroxylon obliquum* was once an important constituent if one may judge from the number of stumps which are to be found. At present there is a little small timber from the larger trees of *Schotia latifolia*, *Cassine crocea*, *Calodendrum capense*, *Harpephyllum caffrum*, *Podocarpus falcatus*, *Rhus legati*, *Scolopia* spp. and *Vepris lanceolata*, but in general the use of this type remains restricted to wattles, firewood and fodder. Undergrowth, shrubs and young trees provide some browsing, but most of the foliage by far is out of reach of stock.

Visibility between the trees is about 25 yards. Because of the density of the trees there is a plentiful supply of litter, and the resulting mould forms a soft and porous cushion over the surface of the ground. Hence in spite of overgrazing and heavy trampling, erosion to a certain extent is checked by a covering which originates out of reach of the stock. The undergrowth consists mainly of *Asparagus* spp. and members of the *Acanthaceae*. There is one representative of the various species of Plectranthus which are found in the higher woodland types—*Plectranthus* sp. near *Plectranthus thunbergii*—a prostrate form with leaves almost fleshy. One or two species of ground ferns occur as rarities.

Acacia is absent in the bush itself but fairly prominent round the margins where tree growth is more open and made up of the light-demanding species like *Gymnosporia buxifolia*, *Ehretia rigida*, *Rhus pyroides*, *Olea africana* and *Putterlickia pyracantha*. Younger trees of other species indicate that this marginal scrub is giving way before an invasion of the taller growth. There is even at the upper margins practically none of the macchia so characteristic of the higher forest types, but instead there may be a rough mixture of tall and short bushes together with the herbaceous *Gamolepis chrysanthemoides* and the grasses *Hyparrhenia buchananii* and *Cymbopogon marginatus*.

Apart from stragglers, mainly *Panicum maximum*, the only grasses found in the bush itself are *Stipa dregeana* and the forest grass *Oplismenus hirtellus*, but near the edges where the vegetation is more open one frequently comes across mats of the fine-leafed and short *Danthonia curva* growing where the bushes cast a light shade. Those round the margin are the same as those associated with types 1, 2 and 3, that is, a mixture of Panicum, Themeda and Digitaria. However, at the upper margin members of an entirely different grassland type may be found—the type known as sourveld, and a sign of the moister conditions of the higher altitudes. The grasslands are discussed in a later chapter. It must be emphasised that the sourveld species are usually uncommon, so that a search may be necessary before they are found, usually between boulders or in parts fenced off from the grazing lands. The ones most likely to be seen are *Harpechloa falx* and *Tristachya hispida*. They mark the end-point of what is often known as scrub or bush, and the beginning of forest.

There is a gradual thinning of types 1 to 4 in their transition to open grassland which presented difficulty in the preparation of the vegetation map and made their delineation a tedious and troublesome work. In the forest zone the tree growth was easy to plot, for it was clearly differentiated from the grassland, or from the macchia when macchia was present, so much so that the clearness or otherwise of the boundary was found to be a useful guide in deciding the affinities of the woodland (see also page 140).

Table 25

BELT TRANSECT FIGURES

ZANYOKWE BUSH (TYPE 4)

Area: 4×608 sq. yds.

Stems Listed: 1 inch diameter breast height and over.

Species	Total Stems	Av. Ht.	Av. Diam.	Max. Ht.	Max. Diam.	Per cent Freq.
		Ft.	Ins.	Ft.	Ins.	
Allophylus decipiens	18	15·6	1·6	20	3	2·04
Asparagus sp.	1	12	1	12	1	0·11
Azima tetracantha	118	14·3	1·2	30	2	13·37
Calpurnia sylvatica	4	11·3	1·5	12	2	0·45
Capparis citrifolia	70	16·6	1·5	25	4	7·94
Capparis rudatisii	1	15	1	15	1	0·11
Cassine crocea	31	21·6	6·1	30	18	3·53
Cassine sp.	49	19·5	3·9	30	13	5·56
Chaetacme aristata	67	11·8	1·6	20	4	7·60
Cussonia spicata	6	19·2	3·3	24	5	0·68
Dovyalis zeyheri	3	20	4	24	7	0·34
Ehretia rigida	43	11·2	1·5	20	3	4·88
Entada natalensis	2	10	1	10	1	0·23
Euclea sp.	3	14·7	2	18	3	0·34
Euclea undulata	26	21·7	5·4	30	10	2·95
Grewia occidentalis	9	12·4	1·3	18	2	1·02
Gymnosporia buxifolia ..	19	10·5	2·2	18	6	2·15
Gymnosporia nemorosa ..	8	10	1·4	10	3	0·91
Gymnosporia undata ..	50	19·5	5·2	25	12	5·67
Hippobromus pauciflorus ..	63	15·4	1·6	25	4	7·14
Jasminum multipartitum ..	6	20·5	1	25	1	0·68
Maerua racemulosa	8	11·6	1·1	18	2	0·91
Olea africana	1	25	5	25	5	0·11
Pappea capensis	13	20·5	4·8	30	12	1·47
Pleurostylia capensis ..	2	11	2	13	2	0·23
Ptaeroxylon obliquum ..	19	18·2	3·1	25	10	2·15
Putterlickia sp.	10	9·4	1	12	1	1·13
Rhoicissus cuneifolia ..	12	21·7	1·2	25	2	1·36
Rhus pyroides	85	9·8	1·7	18	9	9·64
Rhus refracta	2	14·5	1·5	20	2	0·23
Royena lucida	3	16	1·7	18	3	0·34
Royena sp.	10	17·2	1·1	20	2	1·13
Schotia latifolia	55	18·7	4·6	30	18	6·35
Scolopia zeyheri	2	19	3	24	4	0·23
Scutia myrtina	34	10·7	1·4	24	4	3·85
Sideroxylon inerme	9	18·7	4·2	24	6	1·02
Teclea natalensis	19	13·4	2·1	18	5	2·15
Vepris lanceolata	1	25	14	25	14	0·11
Totals	882					100·01

Table 26

ADDITIONAL SPECIES

ZANYOKWE BUSH (TYPE 4)

Woody plants (*a*) too small to be listed in the transect
or (*b*) noted outside the transect
or (*c*) noted in the same bush type elsewhere in the district.

Acokanthera venenata
Apodytes dimidiata
Buddleja salicifolia
Burchellia bubalina
Calodendrum capense
Canthium mundtianum
Canthium obovatum
Canthium ventosum
Carissa bispinosa
Catha edulis
Cissus cirrhosa
Clausena inaequalis
Dracaena hookeriana
Embelia ruminata
Encephalartos altensteinii
Eugenia zeyheri
Fagara capensis
Harpephyllum caffrum
Heeria mucronata
Heteromorpha arborescens
Jasminum angulare
Mimusops obovata
Ochna arborea
Ochna atropurpurea
Osyridicarpos natalensis
Pavetta capensis
Plumbago capensis
Podocarpus falcatus
Podocarpus latifolius
Psychotria capensis
Pterocelastrus tricuspidatus
Rapanea melanophloeos
Rhoicissus digitata
Rhoicissus rhomboidea
Rhus legati
Royena villosa
Scolopia mundii
Secamone alpini
Secamone frutescens
Tecomaria capensis
Trichocladus ellipticus
Trimeria rotundifolia
Trimeria trinervis

TYPE NO. 5—DRY FOREST

COMPOSITION

An example of type 5 is to be found at Lenye Forest Station, which has at its lower limits an annual rainfall of about 29 inches. As distinct from the first four, type 5 may be taken as true forest, although a dry variety of it. This is indicated, besides by the points which follow, by the fact that *Turacus cory-* *thaix* and *Poicephalus robustus*, both forest birds and absent from the drier types, are well represented here. It is only when one is close enough to distin- guish the separate species of trees that one can establish the type to which the forest belongs, but although at a distance there is no difference in appearance between it and the high forest (type 6), its identity can usually be judged by the patches of tree Euphorbias in the neighbourhood outside it, or by a growth of Acacia in clearings and on its margins.

The kloofs are for the most part dry, but some have small streams which run for part of the year and along them are good specimens of forest trees and a few examples of *Xymalos monospora* which is typically absent from this type. Even if the vegetation is open, permanent streams in the immediate vicinity of type 5 do not as a rule have any of the *Combretum salicifolium* which accompanies those in the drier types. As Combretum is a tropical genus, its absence may be bound up with the lower temperatures recorded in type 5 (Tables 5, 6, pp. 11, 12). It has been found to border the streams from the Karroid Broken Veld (as discussed on p. 32) to the lower limit of forest country, and to mark this lower limit with a fair degree of accuracy.

The level of the canopy as a whole is about 40 feet. The average height of all trees as given by the transects is 20 feet, and visibility is more or less the same as in type 4, 20 yards or thereabouts.

Pappea capensis, common in types 2 and 3 and scattered in type 4, drops out here, but a dry character is still manifest from the presence of *Cassine crocea*, *Schotia latifolia*, *Olea africana* and *Dovyalis zeyheri* among the trees and *Plumbago capensis* and *Croton rivularis* among the shrubs. Forest trees are plentiful but from the transect it appears that they are not as strongly represented as the bush and scrub species. *Grewia occidentalis* has the highest frequency of all, and notwithstanding its occurrence in high forest it is more a plant of the dry and hot areas throughout the eastern Cape. A bush in these parts, it takes on the form of a scrambler in the forests. The climbing habit of *Azima tetracantha* which becomes apparent in type 4 is here better developed, and the long straggling branches make their way through loops and characteristic zig-zags to the lower tree-tops where they produce a dense and leafy growth. *Entada natalensis* reaches a diameter of 6 inches and a length of 50 yards. It has many branches that may coil and twist over the forest floor for half their length before ascending to the crowns of the highest trees.

The forest has areas which are a dense tangle of live and dead lianes, in places interwoven and greatly cutting down the light, and often in the form of a low and gloomy arch with the rotted remains of the supporting tree underneath it. These more or less impenetrable piles of trash give a general impression of a brown tangle of vegetation, consisting mostly of stems half an inch thick with about half their number dead. A dense litter of twigs and leaves accumulates, and tree seedlings are absent almost entirely (photograph 21). This is probably because of the dark conditions, for Phillips in his work in the Knysna forests (1931, p. 205) has supported with experimental data his statement: ". . . the absence of regeneration in its various stages, or the poor growth of such regeneration as does exist, is to be attributed to insufficiency of light." There is a negligible amount of undergrowth in such places. Most species of lianes, however, seem to be capable of withstanding this weak illumination and various-sized seedlings may be found in the most deeply-shaded spots.

Except on these dark parts of the forest floor, the undergrowth is thick and consists mainly of members of the *Acanthaceae*, ground ferns, *Plectranthus* spp. and *Asparagus* spp., commonly *Asparagus virgatus*, with grasses where a break in the canopy allows stronger light to penetrate. *Stipa dregeana* is the commonest one and forms a sward in places. *Panicum maximum*, *Panicum deustum* and *Oplismenus hirtellus* occur sporadically (see photograph 22).

There is a deep layer of leaf mould, and fresh litter and fallen trees are rapidly broken down by numbers of saprophytic fungi which thrive under the fairly humid conditions inside the forest. Among the more conspicuous are *Polyporus gilvus*, *Stereum lobatum* and *Polystictus sanguineus*. Below type 5 they are not noticeable. *Streptocarpus rexii* is commonly found here for the first time, growing on the ground or on the rocks, where with the help of the mosses it covers even vertical faces with a deep blanket of vegetation suitable for the establishment of ferns, *Plectranthus* spp. and small trees.

The following is a list of the lianes and smaller creepers which occur:—

Asparagus spp.	*Jasminum angulare*
Azima tetracantha	*Kedrostis* sp.
Behnia reticulata	*Rhoicissus cuneifolia*
Buddleja dysophylla	*Rhoicissus digitata*
Capparis citrifolia	*Rhoicissus rhomboidea*
Capparis rudatisii	*Royena* sp.
Cassine tetragona	*Sarcostemma viminale*
Ceratiosicyos ecklonii	*Secamone alpini*
Cissus cirrhosa	*Secamone frutescens*
Cissampelos torulosa	*Scutia myrtina*
Coccinia quinqueloba	*Senecio angulatus*
Cynanchum sp.	*Senecio deltoideus*
Dioscorea sylvatica	*Senecio macroglossus*
Embelia ruminata	*Senecio tamoides*
Helinus integrifolius	

Epiphytes are abundant throughout (photograph 22). The commonest are lichens, leafy mosses, *Polypodium polypodioides* and *Peperomia reflexa*. *An-graecum mystacidii* appears to be absent, but *Polystachya ottoniana* is present in small amounts.

Growing round the lower margins and mingling with the predominating Themeda-Panicum-Digitaria mixture there are often members of the sourveld grasses, with corresponding non-grasses like *Dobrowskya scabra*, *Lobelia erinus* and *Schistostephium* spp. These are found in contact with the upper margin to the exclusion of the typical sweetveld species, and in addition there is a growth of macchia almost invariably, made up of *Cliffortia linearifolia* or, in one of the drier localities, *Passerina filiformis*. These species are below the range of the *Cliffortia paucistaminea* and *Erica brownleeae* which are the fringing species of the higher altitudes.

SUCCESSION

At altitudes up to about 2500 feet the commonest pioneer tree of this type is Acacia. Occasionally clumps of trees may be built up in the open round a nucleus of *Scutia myrtina* or *Azima tetracantha*, but the usual development of forest follows in essentials the pattern described by Bews (1917a)—open grassland becomes invaded by scattered Acacia, which gives protection and shelter to seedling forest trees. The seedlings grow up to form bush clumps, shading and killing the Acacia in the process, and spreading outwards until they merge and form an unbroken community. Without the Acacia the forest would probably spread more slowly than it does. Under a single dying Acacia tree near the forest margin in the hills above Debe Nek the following plants were found:—

Allophylus decipiens	*Pavetta lanceolata*
Apodytes dimidiata	*Podocarpus latifolius*
Burchellia bubalina	*Protorhus longifolia*
Canthium ciliatum	*Putterlickia* sp.
Canthium obovatum	*Randia rudis*
Canthium ventosum	*Rapanea melanophloeos*
Carissa bispinosa	*Rhoicissus cuneifolia*
Cassine sphaerophylla	*Rhus legati*
Fagara capensis	*Rhus pyroides*
Gardenia neuberia	*Rhus undulata*
Grewia occidentalis	*Royena lucida*
Gymnosporia buxifolia	*Royena simii*
Gymnosporia nemorosa	*Royena villosa*
Halleria lucida	*Scolopia mundii*
Jasminum angulare	*Scolopia zeyheri*
Ochna sp.	*Scutia myrtina*
Olea africana	*Secamone alpini*
Olea laurifolia	*Secamone frutescens*
Osyridicarpos natalensis	*Trimeria rotundifolia.*

This makes a total of 38 species; individuals were so many that it was impracticable to count them. An idea of their number may be gained from the fact that a young four-foot Acacia in this vicinity had 36 separate forest seedlings growing beneath it. In the open grassveld none were seen.

EFFECTS OF GRAZING

If there has been uncontrolled and heavy stocking in type 5, its contrastingly open appearance is striking. Bushes and trees are denuded of every available leaf and even the twigs are chewed. Trees with a single stem are mushroom-shaped, with the lower edges of the branches evenly shorn off at the limit of the animals' reach. Those with a shrubby or denser growth form, and especially those which are in addition thorny, are eaten into the form of a cone. The centre of the bush, being less accessible, has a slightly better chance of growth, but towards the edges the damage becomes progressively more severe, and the constant pruning of all shoots growing outwards forces the growth away from the periphery. Any side branches from the taller central portion are likewise checked until they have been carried upwards into safety. The final growth form is a characteristic hour-glass shape, and the stages are shown in photographs 12 and 13. Similar effects of browsing on tree growth have been reported from Germany by Walter (1927, p. 187).

Different species are grazed without discrimination provided that they are not actually poisonous, and even the poisonous ones do not escape completely. Leaves of *Acokanthera venenata* are occasionally taken notwithstanding their high toxicity (Steyn, 1934, p. 330) and the fact that they have a burning taste (Watt and Breyer-Brandwijk, 1932, p. 142).

The mixed undergrowth gradually disappears until the ground becomes bare except for the covering of litter which has been described under type 4. This stage remains more or less stable until the canopy begins to break down because of the death of the older trees or because of felling. Where the gaps allow sufficient light to reach the ground, a mat of *Cynodon dactylon* and *Sporobolus capensis* is often able to spread, and in time the forest takes on the appearance of a park, with the clean-boled trees widely spaced, a close-grazed lawn, and bushes grotesque in shape through continuous cropping, calling to mind the topiary art of formal gardens. *Senecio juniperinus* is a common weed in bare places, and makes a conspicuous show with its bright yellow heads during mid-summer.

The need of the Native population is for timber and wattles and this causes the more useful trees to be removed first. As the soft and spongy wood of *Cussonia spicata* is of little use (Sim, 1907, p. 230), this tree is saved from the destruction which overtakes the timber trees and its high relative frequency is a feature of the heavily exploited forests.

Under normal conditions the death of a mature tree inside a forest provides a clear space ideally suited to a growth of seedlings of all descriptions, and soon after the establishment of a cover of quick-growing herbs or grass, the young trees make an appearance and a dense stand of saplings grows up. Regeneration in the forests examined was vigorous and adequate even during the 1949 drought, provided that the area was protected from destruction by stock. Examples were numerous in the protected patch on Chulu Ridge 2 miles south of the house at Chatha Forest Station. There are no photographs or analyses to show the appearance of the protected patch when the fence was first put up, but this lack is to a great extent made good by the existence of an unfenced forest half a mile to the south. Both patches belong to type 5 and for practical purposes are identical in size, slope, shape and altitude. When studied with respect to each other they give one the clearest picture possible of how forest can be destroyed by man and his stock. These points are shown in photographs 23–26.

The tree seedlings which are coming up in the glades of the protected forest (mostly *Ptaeroxylon obliquum*, *Brachylaena* sp. and *Buddleja salicifolia*) show that there is a definite tendency for an encroachment of the forest upon the grassland.

Table 27

BELT TRANSECT FIGURES

DRY FOREST (TYPE 5)

Area: 4×608 sq. yds.

Stems Listed: 1 inch diameter breast height and over.

Species	Total Stems	Av. Ht.	Av. Diam.	Max. Ht.	Max. Diam.	Per cent Freq.
		Ft.	Ins.	Ft.	Ins.	
Acokanthera venenata ..	2	12	1	12	1	0·24
Allophylus decipiens ..	73	14·6	1·8	25	5	8·66
Azima tetracantha	26	13·3	1·3	40	4	3·09
Brachylaena sp.	2	18	3	24	5	0·24
Buddleja salicifolia	5	30·8	5·2	45	12	0·59
Calodendrum capense ..	2	25	5·5	30	9	0·24
Calpurnia sylvatica	5	12·8	1·4	14	2	0·59
Canthium sp.	3	34·7	3	40	5	0·35
Canthium ventosum	1	15	1	15	1	0·12
Capparis citrifolia	13	24·1	1·6	40	3	1·55
Cassine papillosa	2	12·5	1	15	1	0·24
Cassine sp.	10	16·8	2	25	4	1·19
Celtis kraussiana	12	26·9	4·9	60	24	1·42
Chaetacme aristata	81	14·8	1·9	30	6	9·62
Clausena inaequalis	11	13·6	1·9	24	4	1·31
Cryptocarya woodii	12	19·1	2·8	30	6	1·42
Curtisea faginea	1	40	6	40	6	0·12
Cussonia spicata	19	32·3	10·3	40	36	2·25
Dovyalis zeyheri	3	31·7	4·3	40	6	0·35
Dracaena hookeriana ..	31	5·4	1·1	8	2	3·68
Embelia ruminata	1	24	2	24	2	0·12
Entada natalensis	11	29·3	1·7	35	2	1·31
Euclea sp.	40	18·4	2	50	4	4·75
Eugenia zeyheri	30	13·7	1·8	40	8	3·56
Fagara davyi	4	20·8	2·5	30	4	0·47
Gardenia neuberia	4	14	1	14	1	0·47
Gelonium africanum ..	3	16·7	1·3	24	2	0·35
Grewia occidentalis	95	15·4	1·3	30	3	11·28
Gymnosporia nemorosa ..	36	17·1	2·9	24	9	4·27
Gymnosporia peduncularis ..	6	20	2·7	30	7	0·71
Hippobromus pauciflorus ..	48	17·9	1·6	25	4	5·69
Maerua racemulosa	1	8	1	8	1	0·12
Olea africana	2	21·5	5·5	25	9	0·24
Olea capensis	2	22	3·5	26	6	0·24
Olea laurifolia	6	25	1·8	30	2	0·71
Pavetta lanceolata	1	12	1	12	1	0·12
Pleurostylia capensis ..	5	16·4	4	24	11	0·59
Ptaeroxylon obliquum ..	9	17·4	1·7	24	3	1·07
Putterlickia sp.	11	13·1	1·2	24	3	1·31
Rhoicissus cuneifolia ..	2	32·5	2·5	40	4	0·24
Rhoicissus rhomboidea ..	3	12·7	1·7	14	2	0·35
Rhus legati	10	37	7·6	50	24	1·19
Rhus refracta	31	20·2	3·2	35	8	3·68
Royena lucida	8	18·4	2	35	6	0·95
Royena villosa	7	18·3	1·1	24	2	0·83
Schotia latifolia	37	25·1	6·1	45	24	4·39
Scolopia zeyheri	2	12	1	12	1	0·24
Scutia myrtina	22	27·5	2·1	40	5	2·61
Secamone alpini	1	30	1	30	1	0·12
Secamone frutescens ..	1	18	1	18	1	0·12
Sideroxylon inerme	2	36	4	36	4	0·24
Trichocladus ellipticus ..	79	12·9	1·4	24	5	9·38
Trimeria rotundifolia ..	2	17	1	24	1	0·24
Vepris lanceolata	7	24·8	3·2	40	10	0·12
						99·34
Totals	843					

TABLE 28

ADDITIONAL SPECIES

DRY FOREST (TYPE 5)

Woody plants (*a*) too small to be listed in the transect
or (*b*) noted outside the transect
or (*c*) noted in the same forest type elsewhere in the district.

Buddleja dysophylla
Burchellia bubalina
Capparis rudatisii
Carissa bispinosa
Cassine tetragona
Cissus cirrhosa
Commiphora caryaefolia
Ekebergia capensis
Encephalartos altensteinii
Ficus burtt-davyi
Halleria lucida
Harpephyllum caffrum
Heteromorpha arborescens
Jasminum angulare
Mimusops obovata
Ochna arborea
Ochna atropurpurea
Pavetta capensis
Pittosporum viridiflorum
Plumbago capensis
Podocarpus falcatus
Pterocelastrus tricuspidatus
Rapanea melanophloeos
Rhoicissus digitata
Rhus pyroides
Teclea natalensis
Trimeria trinervis

TYPE NO. 6—MOIST FOREST

COMPOSITION

Type 6 is found in areas where the rainfall averages about 35 inches and upwards, and in a climate appreciably cooler than in the other woodland types (Table 2, p. 8), the highland macchia excepted. Its lower limits are in contact with the sourveld, or alternatively with macchia made up almost exclusively of *Cliffortia linearifolia*, its upper limits border on sourveld, on *Helichrysum argyrophyllum*, or on macchia of *Cliffortia paucistaminea* or *Erica brownleeae*, according to the conditions prevailing. Here, unless the altitude is below 4000 feet, *Cliffortia linearifolia* is never represented as a community but as individuals only, and is rarely seen even in this form.

As has been previously stated, and as may be seen from Tables 21–30, there are some trees which type 6 has in common with the drier types. In habit however they are often distinct. Where found at all under the moist conditions of the forests, the straggling bushes and the stubby, gnarled and branching trees of the drier localities occur as lianes and as slender clean-stemmed trees respectively. This has been mentioned in the descriptions of types 4 and 5 and the difference in habit of *Scutia myrtina* is shown in photographs 13 and 14. Their size is also much greater, and sometimes the leaves are so much larger as to give the impression that different species are involved. *Gymnosporia buxifolia*, thorny and shrubby in the lowlands, is found on the forest margins and on the slopes above them in the form of an umbrella-shaped tree, with spines small and few by comparison.

The height of the canopy is about 50 feet, rising in places to 70 and over where the best specimens of Podocarpus and *Olea laurifolia* grow. Sim (1907, p. 4) records heights of 100 feet for the Amatole trees, and in this connection uses the word "average", but clearly in a loose sense.

As an indicator tree in this forest type, *Xymalos monospora* is the most reliable and widespread. *Cunonia capensis*, *Strophanthus speciosus* and *Englerodaphne pilosa* are also confined to type 6 but occur patchily and are easily missed in consequence. A peculiar feature of these forests is the enormous quantity of *Trichocladus ellipticus* in them. Transect figures show that nearly half the stems measured were of this species, and because it is a slender tree, there were in addition very many too small to be included in the transect figures. Their number does not strike one until a count is made, for one's attention is liable to be taken up disproportionately by the larger and more striking trees. Trichocladus has wood of an unusually brittle nature which snaps easily during storms. Many of the larger specimens are in consequence broken about the top, and the tree does not pierce the forest canopy.

The undergrowth is unmistakably different from that of type 5 in spite of the fact that the *Acanthaceae*, as in the drier types, make up a large proportion of it. Ferns are richer in numbers and species and are usually common throughout. Even the various species of Adiantum may here be seen growing away from the stream banks which are their normal habitat in type 5. Conspicuous and common plants are *Plectranthus krookii* and *Plectranthus fruticosus*, in places intermixed and forming tangles of sappy growth, others of about the same height being *Galopina circaeoides*, *Euphorbia epicyparissias*, *Euphorbia kraussiana*, *Desmodium scalpe* and *Thalictrum* spp. In undisturbed forest they make a rather even covering which hides the quantities of old and rotting wood on the floor, and its inequalities. Grasses and sedges are of minor importance. The following species are those most often seen: of the grasses, *Stipa dregeana*, *Oplismenus hirtellus* and *Brachypodium flexum*, and of the sedges *Cyperus teneriffae* and *Schoenoxiphium sparteum*. There is a ground layer of low-growing plants as well, including typically *Hydrocotyle asiatica*, *Diclis reptans*, *Sanicula europaea*, *Polygala confusa* and *Streptocarpus rexii*. A layer of mould forms an unbroken covering to the soil. The only really conspicuous flower in the shady parts of the forest floor is *Streptocarpus rexii*. *Nerine alta* can also grow in poor light and is showy when it comes into bloom in the late summer, but it favours the more open parts where it adds variety to the patches of *Zantedeschia aethiopica*, *Kniphofia* spp. and *Ornithogalum lacteum* which are also plants of the more open situations.

Visibility is as a rule poor, and may be judged from photograph 27. Mr. R. A. Hoyle is standing about one yard to the left of the large Podocarpus bole on the right edge of the picture, and is less than ten yards from the camera.

Moles and earthworms show their presence by their mounds and castings in all parts of the forest. Bordered as the forests are by the Native settlements, it follows naturally that game is almost absent through poaching by men and dogs, and it is only the birds and monkeys which remain plentiful. Characteristic birds are *Poicephalus robustus*, *Columba arquatrix* and *Turacus corythaix*. The habits of the last two have a bearing on seed dispersal in the forests and have been the subject of papers by Phillips (1927 and 1928b). During the summer one is seldom out of earshot of the call of *Chrysococcyx cupreus* which abounds in all the high forests of the Amatole range. According to a note in the Albany Museum guide (1931, p. 164) one may expect to hear it roughly between September and February. Gill (1945, p. 108) states that it has been described as "the most dazzlingly beautiful bird in Africa", but it is shy and seldom seen. Essentially a bird of the dense forest only is *Motacilla clara*, which frequents "rocky streams in thick bush or forest and apparently never leaves such sheltered spots" (Albany Museum guide, 1931, p. 91). It is rare in the Keiskammahoek district.

The saprophytic fungi are plentiful and play their part with the woodpeckers and boring insects in breaking down the dead trees into the soft and crumbly humus mentioned previously.

There is no lack of surface water, for perennial streams run down all the larger kloofs. *Ilex mitis* grows only on their banks or in the streams themselves, and is in this respect unique amongst the trees of the Amatole forests, for the others, although they may and often do grow next to Ilex in the streams, grow equally well elsewhere, which indicates that the presence of an unlimited water supply is not a necessity to them. Most of the water comes originally from the mountain slopes above the present timber line but occasionally it has its source in marshy areas inside the forest. If they are level or nearly so they become waterlogged, and connected with this more or less stagnant water is some factor lethal to trees, so that even *Ilex mitis* cannot live in such places. There is nevertheless a strong and unceasing tendency on the part of the trees to invade the area and if there is any suitable change in the conditions prevailing they readily do so. They grow with varying success but sooner or later most succumb, and the consequence is that these open spaces are dotted with skeleton trees which afterwards fall and become half-buried in the existing vegetation.

Where the seepage areas are on a slope and the water is able to flow, tree growth is normal. The ground vegetation then consists of a mixture of hygrophilous bushes, herbs and ferns, *Hypolepis sparsisora* and *Englerodaphne pilosa* prominent among them, and if seen along the margins of the forest roads a sign of a sticky patch and of bad driving conditions in wet weather. A species of Impatiens is also common, growing best in saturated ground, often in company with carpets of *Selaginella kraussiana* and *Lycopodium clavatum*. On the margins of the running water sedges are frequent but inconspicuous, barring *Carex petitiana* which has culms up to three feet long and large nodding inflorescences.

The Impatiens which as been mentioned, common and widespread in the eastern Cape, has for many years been known as *Impatiens capensis* Thb., but according to Burtt (1938, pp. 161–3) the name is not valid for the South African species, and there is as yet no other name which may be substituted. There is a specimen from Keiskammahoek in the National Herbarium, Pretoria (Story No. 3261).

The level bogs referred to bear a distinct vegetation and are discussed on page 100.

SUCCESSION

Acacia karroo is not found with this type. The commonest pioneer tree is *Rapanea melanophloeos*, which, while a member of the interior of the forest, is also well able to grow in the open and provide shelter for those species less tolerant than itself. It cannot however stand the hotter conditions which suit Acacia, nor can Acacia thrive where Rapanea grows, and the transition between types 5 and 6 is often clearly shown by the distinct boundary between these two species on the forest outskirts. The dividing line is usually accentuated by the open appearance of the mixed grass and shrubs between the Acacia, and the dense growth of *Cliffortia linearifolia* in the environs of type 6. Different trees may assume the functions of pioneers sporadically, and, as far as can be seen, by chance, and Rapanea certainly does not have the great preponderance over other associated pioneers that Acacia has in the drier parts. The following list gives an idea of the variety of forest trees which are habitually able to grow in the open under the milder climatc conditions which prevail in the neighbourhood of the higher forest types:—

Apodytes dimidiata
Brachylaena sp.
Buddleja salicfolia
Buddleja salvifolia
Burchellia bubalina
Calpurnia sylvatica
Canthium ciliatum
Carissa bispinosa
Cassinopsis ilicifolia
Cussonia spicata
Dovyalis zeyheri
Gymnosporia buxifolia
Halleria lucida
Lachnopylis floribunda
Metalasia muricata
Osyris compressa
Pittosporum viridiflorum
Podocarpus falcatus
Podocarpus latifolius
Rapanea melanophloeos
Rhamnus prinoides
Rhus dentata
Rhus legati
Rhus pyroides
Royena lucida
Scutia myrtina.

Calpurnia sylvatica usually forms definite consocies and occasionally *Rapanea melanophloeos* shows this tendency also. With these exceptions the trees are not grouped into any recognisable pattern but grow as individuals, sometimes evenly mingled and sometimes with one or two species more numerous than the others.

Where the forests are not fenced, the young trees, under the present conditions of stocking, are continually suffering setbacks from the damage done by grazing animals. Because of this, it is the thorny bushes which are least molested, and which consequently offer the most favourable conditions to the growth of tree seedlings in their shelter. Clean-boled or unarmed trees may indeed have entirely the opposite effect from the theoretical one of acting as nurses to a denser tree growth, for as they grow taller and shadier, so do the stock tend increasingly to congregate beneath them in the heat of the day, with the result that existing seedlings are destroyed by trampling and no new ones are able to grow. This is shown in photograph 29. On the other hand, a 5-foot *Carissa arduina* in the same locality in which the photograph was taken had the following small trees growing under protection:—

Grewia occidentalis
Pittosporum viridiflorum
Ptaeroxylon obliquum
Randia rudis
Rapanea melanophloeos
Rhamnus prinoides
Rhus legati
Scutia myrtina.

To summarise: trees growing in the open are theoretically and potentially the fore-front of an advancing area of forest, but where stocking is heavy this function falls away unless the trees in question are armed or shrubby. There are few such trees in type 6. The transect figures show that they make up only 12·54 per cent of the total, in contrast with 44·06 per cent in type 2. That is why one finds that heavy stocking tends to increase the woody growth in scrub, and decrease it in the forests (see photograph 28).

TABLE 29

BELT TRANSECT FIGURES

MOIST FOREST (TYPE 6)

Area: 4×608 sq. yds.

Stems Listed: 1 inch diameter breast height and over.

Species	Total Stems	Av. Ht.	Av. Diam.	Max. Ht.	Max. Diam.	Per cent Freq.
		Ft.	Ins.	Ft.	Ins.	
Apodytes dimidiata	3	31·6	8·6	50	24	0·37
Burchellia bubalina	6	20·3	2·5	30	4	0·74
Calodendrum capense	2	75	27	80	36	0·25
Calpurnia sylvatica	1	25	2	25	2	0·12
Canthium ciliatum	12	16·5	1·4	24	2	1·47
Canthium obovatum	4	25·5	2·5	36	4	0·49
Canthium sp.	3	18·6	1·6	20	2	0·37
Cassine papillosa	4	17	1	20	1	0·49
Celtis kraussiana	9	43	12·4	65	24	1·11
Cryptocarya woodii	9	22·2	2	30	5	1·11
Curtisea faginea	11	42·7	9·8	60	36	1·35
Dovyalis lucida	7	14·4	1·1	20	2	0·86
Dovyalis zeyheri	1	45	18	45	18	0·12
Eugenia zeyheri	1	8	1	8	1	0·12
Fagara davyi	19	36·4	5·4	60	18	2·34
Gardenia neuberia	34	12·7	1·6	20	3	4·18
Gardenia rothmannia	8	25·9	3·2	50	6	0·98
Grewia occidentalis	1	30	1	30	1	0·12
Gymnosporia acuminata	5	30·2	5·4	36	9	0·62
Gymnosporia deflexa	3	22	2·3	30	3	0·37
Gymnosporia peduncularis	4	29·5	4·5	40	10	0·49
Gymnosporia nemorosa	17	20·2	2·3	30	6	2·09
Halleria lucida	3	22	8·3	30	12	0·37
Ilex mitis	1	30	3	30	3	0·12
Kiggelaria africana	8	38·6	8·1	50	12	0·98
Mimusops obovata	4	18	1·5	24	2	0·49
Ochna arborea	21	17·6	2	60	9	2·58
Olea capensis	4	26	3	36	5	0·49
Olea laurifolia	56	25·2	3·7	90	36	6·88
Pavetta lanceolata	1	10	1	10	1	0·12
Pittosporum viridiflorum	1	8	1	8	1	0·12
Pleurostylia capensis	8	27·2	2·7	36	6	0·98
Podocarpus falcatus	9	49	24·7	100	60	1·11
Podocarpus latifolius	20	38·4	12	100	60	2·46
Psychotria capensis	1	30	3	30	3	0·12
Ptaeroxylon obliquum	1	48	12	48	12	0·12
Rapanea melanophloeos	5	18	1·4	24	2	0·62
Rhoicissus cymbifoliolus	1	25	1	25	1	0·12
Rhus legati	16	36·2	5·8	55	24	1·97
Rhus lucida	2	12	1	12	1	0·25
Royena lucida	13	23·8	2·6	40	6	1·60
Scolopia mundii	4	29·2	3·5	40	7	0·49
Scolopia zeyheri	6	21·7	1·7	40	3	0·74
Scutia myrtina	10	43	3	60	6	1·23
Secamone alpini	2	35	1	40	1	0·25
Trichocladus ellipticus	369	20·2	2·1	55	9	45·33
Vepris lanceolata	14	23·6	2·9	40	18	1·72
Xymalos monospora	70	29·6	6·8	60	24	8·60
Totals	814					100·02

TABLE 30

ADDITIONAL SPECIES

MOIST FOREST (TYPE 6)

Woody plants (*a*) too small to be listed in the transect
or (*b*) noted outside the transect
or (*c*) noted in the same forest type elsewhere in the district.

Acokanthera venenata
Allophylus decipiens
Andrachne ovalis
Bowkeria sp.
Brachylaena sp.
Buddleja dysophylla
Buddleja salicifolia
Buddleja salvifolia
Canthium ventosum
Carissa bispinosa
Cassine tetragona
Cassinopsis ilicifolia
Chaetacme aristata
Choristylis rhamnoides
Cissus cirrhosa
Clausena inaequalis
Commiphora caryaefolia
Cunonia capensis
Cussonia spicata
Dovyalis rhamnoides
Dracaena hookeriana
Embelia ruminata
Encephalartos altensteinii
Englerodaphne pilosa
Ficus capensis
Gardenia thunbergia
Gelonium africanum
Heteromorpha arborescens
Hippobromus pauciflorus
Jasminum angulare
Lachnopylis floribunda
Maerua racemulosa
Ocotea bullata
Osyridicarpos natalensis
Pavetta capensis
Pterocelastrus tricuspidatus
Putterlickia sp.
Pygeum africanum
Rhoicissus capensis
Rhoicissus cuneifolia
Rhoicissus digitata
Rhoicissus rhomboidea
Rhus dentata
Rhus pyroides

TYPE NO. 7—MACCHIA

GENERAL

IN THE WORLD AS A WHOLE

Macchia is perhaps best known from the Mediterranean region of Europe, where it is the characteristic vegetation. During World War II it gave the French form of its name to the Resistance movement, and although in this way millions became acquainted with the word, probably the greater part of the English-speaking ones had no idea of its derivation. There are various objections to the term *macchia*, but it is probably better known than the South African term *fynbos*, and is accordingly used by preference in this paper. In spite of the fact that its component species differ from place to place, one is justified in calling it macchia as long as its growth form is unchanged, for the word refers only to its growth form and not to its floristic composition. In South Africa it is the dominant formation of the winter-rainfall region of the south-western Cape Province. Besides in the Mediterranean region and in the western Cape, a similar formation of sclerophyll shrubs is found:—

1. In the highlands of tropical America, in places where the soil is apt to become frozen (Beard, 1944, p. 133).

2. In Java, on the mountain Pangerango (Schimper, 1903, pp. 724-5). The plants here are chiefly *Anaphalis javanica* (*Compositae*), which forms an Alpine woodland at an altitude of about 3000 metres (9840 feet). Schimper's photograph of this woodland could pass easily for one of the highland macchia at Keiskammahoek. His description applies equally well:—"Beyond the elfin-wood, almost completely covering the summit of the mountain, is a dense mass of shrub, taller than a man, with small,

TABLE 31

SUMMARISED FIGURES FOR HALF-ACRE TRANSECTS

Type	Species	Stems	Per cent Spiny Stems	Maximum Height	Average Height	Maximum Diameter	Average Diameter
2	21	295	44·1	14	8·0	8	2·1
3	42	683	28·1	25	12·5	24	2·1
4	39	882	34·8	30	15·9	18	2·8
5	53	842	23·9	60	20·2	36	2·6
6	48	814	12·5	100	27·9	60	4·9

or at most middle-sized, leaves which are all xerophlious in structure . . . The dominant shrub is the woolly *Anaphalis javanica*, which growing socially, often entirely excludes all other woody plants. . . Here and there the scrub on the summit is interrupted by Alpine steppe, the chief constituents of which are narrow-leaved, short grasses." Like the Amatole range, this region has a summer rainfall.

3. In Uganda. On the high mountains where trees are absent, Ericaceous species may form a subalpine community (Snowden, 1933, p. 24), sometimes associated with *Protea abyssinica* and *Anthospermum pachyrrhizum* (Thomas, 1943, pp. 162–3). The boundary between this formation and the forest below it is at about 2400 metres (7870 feet).

4. In Tanganyika, where small groves of *Erica arborea* grow near the Alpine zone of Kilimanjaro (Schimper, 1903, p. 738).

5. In Australia, the sclerophyll leaf being here typical of the Mediterranean climate of the south-west, but occurring also in desert scrub and in regions with a rainfall of 40 inches (Bews, 1927, p. 76; Wood, 1934, p. 70).

6. In the British Isles "on exposed high-lying peat moors, which are not too wet, but where trees cannot grow, it is the climatic climax" (Tansley, 1923, p. 55).

7. On mountain tops throughout the Union of South Africa and the adjacent territories (Bews, 1916, 1917b; Liebenberg ms.; Levyns, 1938; Rennie, 1935; Weimarck, 1934).

8. Above the forests on the Pacific islands of Juan Fernandez and Desventuradas (Skottsberg, 1945).

9. In parts of the Falkland Islands (Skottsberg, 1945).

10. In parts of California (Bews, 1927, p. 76).

11. In parts of Chile (Bews, 1927, p. 76).

There is general agreement among those authors who touch on its ecology that macchia is a more xerophytic type of vegetation than forest, and its leaf structure supports this view (see page 125). Its presence in the Mediterranean region and in others where the climate is similar may be explained by the fact that such regions are physiologically dry (Maximov, 1929, p. 266), and its presence in the other places mentioned may be attributed likewise to drought, caused either directly, by lack of rain, or indirectly, by the factors which come into play in cold or windy climates and at high altitudes. The matter is discussed in Chapter 4.

IN THE EASTERN CAPE PROVINCE IN PARTICULAR

In the eastern Cape, it extends westwards along the mountains beyond the Amatole range (where *Cliffortia* spp. and *Erica brownleeae* are co-dominant) as far as the Bosberg, which overlooks Somerset East. The Bosberg variant strongly resembles in growth form and colour the Amatole macchia, and floristically also the two are very nearly related. The dominant bush on the Bosberg is a species of Erica, near *Erica rupicola*. Notes by H. Bolus and L. Kensit on Weale's specimens from Bedford in the herbarium of the Albany Museum indicate that it is probably a new species, differing from *Erica rupicola* in habit, size of corolla and pubescence of ovary. As far as is known, there are no other records of it than those from Somerset East and Bedford. With the Erica are the usual smaller communities and scattered specimens of *Metalasia muricata*, *Restionaceae*, *Aspalathus* spp., *Pteridium aquilinum* and the like. The *Proteaceae* are represented by *Protea macrophylla*. Neither of the Amatole species (*Protea lacticolor* and *Protea multibracteata*) was observed. The vigorous growth of Erica seedlings in burnt areas indicates that the two forms of macchia are probably alike even in behaviour (see pages 84–5)

A peculiar feature of *Erica brownleeae*, and the Bosberg and Bedford species, is that both should be known only from the narrow limits of less than 50 miles of mountain country (see page 81). They may owe their presence to one of the following possibilities:—

1. Parent communities as yet undiscovered.
2. Parent communities since become extinct because of disease or unfavourable climate.
3. Evolution from other species of Erica.

Since the Cape has been well explored botanically, No. 1 is unlikely. As for No. 2, it is virtually inknown for a species to be destroyed by disease, and minor climatic changes also would be likely to result not in annihilation but, in order, in the death of the plants in unfavourable habitats, the death of old and weak plants, and the dwarfing of the later generations (Clements, 1934, p. 44). Major climatic cycles, according to the evidence presented by Smuts (1932) and by van Riet Lowe (1938), are to be measured in thousands and tens of thousands of years. They alone are likely to have caused the destruction of whole plant populations, so complete that no trace of them remains. As for No. 3, the evolution of a species, unless occurring through a sudden mutation, is a process which in respect of time may dwarf even the climatic cycles (Wells, Huxley and Wells, undated, p. 274). Zeuner (1949, p. 251) quotes the palaentological evidence of various authors to show that it usually takes 500,000 years of evolution before an organism is by general agreement classified as specifically distinct from its ancestral form, and the lowest estimate of the authorities mentioned by Riley (1950) is a few thousand years.

Together with the occurrence of macchia on so many of the Union's mountains, these points suggest that macchia is an ancient and normal vegetation type on the Amatole range.

Its general appearance and characteristics having been described by Bews (1929, p. 11); Adamson (1929, p. 16); Pole Evans (1922, p. 49) and others, the giving of a broad picture of the formation as a whole would be unnecessary repetition. What follows will be a more detailed discussion with particular reference to Keiskammahoek.

The plants making up the local macchia are as a rule compact, unarmed, dark green bushes, seldom more than 10 feet in height, profusely and rigidly branched and with ericoid leaves, and the different genera and species may be superficially so much alike that persons not well acquainted with it sometimes make the mistake of thinking that only one species is present. It is not found in places where the average annual rainfall is below 25 inches, but may be expected in any where the rainfall is above this figure, near the 25-inch isohyet in the form of clumps and isolated bushes, and becoming dominant only near the 30-inch isohyet. Its rainfall requirements thus coincide very nearly with those of the sourveld, which in this district it accompanies almost invariably (see Chapter 3). It is never found in the sweetveld. It is made up of three main communities, namely the *Cliffortia linearifolia*, the *Cliffortia paucistaminea* and the *Erica brownleeae* communities. The first community will be considered separately, the remaining two have so much in common that they are most conveniently treated under one heading. To avoid tedious repetition, specific names will be omitted unless the omission gives rise to ambiguity.

THE *CLIFFORTIA LINEARIFOLIA* COMMUNITY

REQUIREMENTS

Dominated by *Cliffortia linearifolia*, this variety of the macchia is the shortest and most uniform of the three. The bushes do not grow more than about 4 feet high, scattered in the early stages of their invasion into grassland

but forming a very dense cover when they are well established. They smooth the irregularities of the ground under a thick olive-green blanket, broken only by the occasional clumps of trees, the cattle-tracks and the roads. The community does not extend much over 4000 feet at Kieskammahoek, reaching its altitudinal limit on the plateau below and to the south-west of West Peak Pirie (4180 feet). Above 4000 feet, *Cliffortia linearifolia* occurs as widely-spaced individuals and not as a community; there is, however, no *lower* limit to communities of it in the eastern Cape, provided the rainfall is adequate. Further north "it occurs in an isolated locality in the Inyanga district of S. Rhodesia, where, according to my own experience, it does not go lower down than 1700 metres (about 5500 feet)". (Weimarck, 1934, pp. 55–6). Doubtless it is prevented from extending its range downwards because of the higher temperatures of the Rhodesian lowlands.

Its requirements for rainfall and altitude are constant for the eastern Cape as a whole, as the following examples show. In those parts of the Albany and Bathurst districts which have a rainfall of about 25 inches, small communities are found in seepage areas, sandy patches and along the edges of roads, where there is a better supply of soil moisture (see pages 32 and 104). Near Collingham Tower, however, where the rainfall is over 30 inches, it is not limited to the moist localities but will grow anywhere in the grasslands. Photograph 30 shows its luxuriant growth in this area. On the Fort Fordyce Forest Reserve and the surrounding highlands of the Adelaide and Fort Beaufort districts (altitude between 3500 and 4000 feet, rainfall 30 inches and over) it is common and beginning to encroach upon the grasslands. West of Fort Fordyce the higher altitude of the mountains seems to be against it. There are a few bushes in the Forest Reserve in the Kaga Mountains north of Bedford (4000 feet and over) and it appears to be absent completely from the Bosberg, Somerset East (5325 feet). On the lower intervening hills round Cookhouse and Daggaboers Nek the altitude is suitable but the rainfall map shows that the rainfall is inadequate, and here it is likewise absent.

Probably bound up with its climatic and rainfall requirements is its tendency to grow better where the aspect is south or south-east. This may be masked by other conditions, so that it is in places indifferent to the aspect, but the *general* truth of the statement is apparent from the fact that in any particular spot it often grows on the mesocline and avoids the xerocline, and that it never grows on the xerocline in preference to the mesocline. It is strongly light-demanding and is not found inside the forests. On the southern margin of the forests where dense shade is cast, it is also not able to grow, or grows in a divaricate form which is positively phototropic. It is more tolerant of seepage areas than *Cliffortia paucistaminea* and *Erica brownleeae*, but although often occupying the low-lying ground which they will not, it avoids any places periodically flooded. It does not for example grow on the bottoms of the *debe* hollows (pages 152–3 and photograph 31) except where they have channels to drain the rainwater away.

PROPAGATION

The plants flower abundantly and it appears that the seed may be produced at any time of the year, for quantities have been collected during January, March, April, June, July, August and November. This, however, requires further investigation, because the seed is not shed as readily as that of *Cliffortia paucistaminea*, and for this reason the collections may have included old seed. The percentage germination has not been established because the seed has so far consistently failed to germinate in the laboratory. At various seasons, attempts have been made with freshly collected and stored seed in soil and on filter paper without result. Weimarck (1934, pp. 161–2) observed that the seed of the species he investigated quickly lost its germinating power. This appears to be the only explanation of the failure of the seed in the tests mentioned, for under natural conditions it germinates well, and at any time of the year provided that it is not cast in deep shade. The dense nature of the bushes themselves and the thick layer of trash which accumulates below them greatly reduce the light at ground level, and in such places no seedlings are to be found, nor, for the same reason, will they grow under a matted accumulation of old grass. But they will germinate and grow even in a dense sward if the grass is short, the reason probably being that short grass intercepts less of the light. There can be no question of an improved water supply in such cases because grass kept short and vigorously growing depletes the soil water more quickly than a rank cover where growth is slow or at a standstill (Theron, undated). There is a slight but definite tendency for a better crop of seedlings to be produced in the bare spaces among the grasses, noticeable not so much where the soil is compact as where it is loose and friable. Ideal conditions are provided by molehills, often large and plentiful in the sourveld (photograph 32). Judging from this, and from its behaviour in the Albany district (photograph 30), one would expect it to be a rapid invader of any abandoned lands in parts where supplies of seed are forthcoming, but photograph 33 shows that this may not happen at Keiskammahoek.

EFFECTS OF GRAZING

If there is an abundance of grass, Cliffortia is avoided by stock and is able to flower and set seed unchecked, but the strong competition from the grass ensures that its spread is a very slow process. With heavier stocking the grass cover is no longer able to hinder the establishment of Cliffortia seedlings, this causing a spreading of the community, slow at first but accelerating as more bushes mature and contribute their share to the seed supplies. This rate of stocking, heavy enough to keep down the grass but not so heavy as to hamper the Cliffortia, provides ideal conditions for the establishment of a dense community. If the rate of stocking is now increased, the animals can make little impression on the stout twigs of the fully-grown bushes, and the result is merely the destruction of the sward, and a slight pruning of the Cliffortia. It is not practicable by controlled grazing alone to convert to grassland areas dominated by Cliffortia. It is necessary to get rid of the Cliffortia first by mechanical means or by burning; then, *when the grassland has been re-established*, the Cliffortia may be kept down by controlled grazing. The land must be very heavily stocked until the grasses are grazed short and the cattle become hungry enough to eat any new growth of Cliffortia that takes place. When the land has been evenly and closely grazed, a period of rest must follow. Such a grazing system does not keep the sward entirely free from it, but it does ensure that the Cliffortia receives no preferential treatment. It is denied the chance of growing into a bush and assumes the form of a dwarf shrublet at the same level as the sward surrounding it. The amount of seed produced by these shrublets is insignificant. After the resting period the cattle will encounter the new shoots while they are still young and sappy and will eat them under the incentive of nothing more than a healthy hunger. Certainly prolonged starvation will not be needed, for *Cliffortia linearifolia* is palatable by comparison with *Cliffortia paucistaminea* and *Erica brownleeae*. The end result is that this plant will make up a proportion of the sprinkling of non-grasses normal in any grassland, and will not spread other than extremely slowly.

The practicability of this method is amply demonstrated at Keiskammahoek, and is shown in photographs 34 and 35. In each photograph the open grassland is heavily and continuously grazed and the part under Cliffortia is grazed lightly by cattle almost exclusively. Close examination of the grassland shows

that Cliffortia is present there also, but unimportant in its effect as a detrimental constituent of the pasture. The treatment of the grazed parts shown in the photographs, however, falls short in that there has been no resting period for them up to the present time. They are now beginning to deteriorate according to the pattern described in the chapter on grasslands, and a system of rotation is urgently necessary.

Fenton (1934) gives an account of a parallel case in pastures in Devonshire, which are invaded by heath and other woody shrubs wherever there is light selective grazing. On 26th July, 1946, Mr. J. P. H. Acocks drew my attention to a similar state of affairs in the sourveld at the top of MacKay's Nek, 20 miles from Queenstown on the road to Lady Frere, pointing out that because of heavy grazing no grass had been unduly weakened at the expense of another, and that in parts more lightly grazed, palatable grasses are apt to be eradicated and unpalatable ones to increase.

EFFECTS OF BURNING

Burning will normally kill Cliffortia except where the bushes are spaced too widely and the grass too closely grazed to allow a hot fire to develop. Under these conditions the bushes readily sprout again from a cluster of shoots at the base of the stem. Although searches have been made for sucker regeneration, none has so far been found. In respect of burning it appears more resistant than *Erica brownleeae*, for it has been seen sprouting, after a fire, in places where the Erica bushes were dead without exception. As a method of control, therefore, burning would be useless if half-heartedly done. A fierce blaze is required, and a sparse growth of Cliffortia would need to be protected until the intervening grasses had made growth enough to provide the necessary fuel. As seedlings come up in abundance in burnt areas, burning would have to be carried out more than once before the land could be expected to remain reasonably clear.

SUCCESSION

At Keiskammahoek it appears that with few exceptions the sourveld pastures below 4000 feet change in the natural course of succession to a woodland community. This is shown by the way in which areas of Cliffortia where protected do not revert to grassland but remain under Cliffortia, and by certain definite signs that Cliffortia increases with protection. These are firstly the presence of seedlings and young plants, and secondly that the mature bushes are able to grow above the grasses (with certain exceptions to be discussed shortly) and kill them by casting a shade too deep for them to live in. Grass tufts under vigorous Cliffortia bushes are as a general rule either dead or moribund, and indicate by this fact that they represent a stage in the succession lower than the Cliffortia community. The increase in Cliffortia takes place very gradually in a protected area, for reasons already given; nevertheless tufts of dead grass do finally rot away and the activities of earthworms, moles, field-mice and rats contribute also to the production of loose open ground where the seedlings can obtain a foothold.

All the evidence so far collected points in the same direction, namely that Cliffortia also, although successionally more advanced than the grasslands, is still not a climax community. The succession advances through a slow influx of *Cymbopogon marginatus* and *Miscanthidium capense*. These tall grasses, indiscriminately known as Tambookie, are the exceptions mentioned, for they are not suppressed by the Cliffortia, but can grow well even where it forms the densest stands. Apparently *Cymbopogon marginatus* at least can become established in very dim light, for it may be seen growing up through the Cliffortia bushes and flowering above them. A good example of a Tambookie area lies to the south of the right of way between Wolf Ridge and the plateau above Lenye Forest Station, about 300 yards east of Forestry Department beacon 126. It is protected by a fence on one side and by a steep ravine on the other, and the absence of cropped grass, of paths, and of droppings all prove that it is seldom disturbed. On the other hand, there are abundant signs of trespassing stock in the glades shown in photograph 34, where all grasses, Tambookie included, are held in check by grazing and trampling, and Cliffortia has undisputed dominance. Another area of Tambookie is on the plateau north of Debe Nek. It is on the margin of a piece of fenced land which is used for growing crops and is hence rarely grazed. There is little Cliffortia within the enclosure. Outside, there is the most luxuriant Cliffortia in the district. One may infer that this community would also go to Tambookie if protected, and the history of the plateau supports this view. There is a coloured woodcutter living here who has known this part since he was a boy of ten or so. He states that in 1900 there were a few Cliffortia bushes next to his family's hut, and that the rest of the country, except where the forests were, was tall Tambookie which extended over his head. It used to be burnt yearly by officials of the Forestry Department. This was undoubtedly what kept the vegetation at the grassland stage (see page 90).

The Cliffortia and Tambookie finally give way to a tangled mixed vegetation, taller and difficult to penetrate. Besides many young forest trees and a scattering of the sourveld grasses, these plants are common:—

Anthospermum lanceolatum	*Psoralea pinnata*
Buchenroedera multiflora	*Psoralea spicata*
Calpurnia sylvatica	*Pteridium aquilinum*
Cymbopogon marginatus	*Rhamnus prinoides*
Leonotis leonurus	*Senecio juniperinus*
Miscanthidium capense	*Syncolostemon densiflorus*
Plectranthus calycinus	*Watsonia* sp.

This stage leads directly to high forest.

A system of controlled grazing which stops the spread of Cliffortia will naturally check the growth of trees as well, but any system, or lack of system, which allows Cliffortia to spread will probably end in the establishment of some type of forest. At the present time, forest is developing in the macchia of the uncontrolled plateau north of Debe Nek, the young trees being for the most part still too small to extend above the macchia but apparent in scores to anyone who walks through it. The following seedlings are represented:—

Brachylaena elliptica	*Rhus dentata*
Buddleja salicifolia	*Rhus legati*
Calpurnia sylvatica	*Rhus pyroides*
Canthium ciliatum	*Rhus undulata*
Cassine sp.	*Royena lucida*
Clematis brachiata	*Royena simii*
Dovyalis zeyheri	*Scolopia flanagani*
Fagara capensis	*Scolopia zeyheri*
Halleria lucida	*Scutia myrtina*
Podocarpus latifolius	*Secamone alpini*
Rapanea melanophloeos	*Strophanthus speciosus.*

Whether or not forest is the climax on *all* the treeless land in the *Cliffortia linearifolia* zone has not yet been established with certainty. The relationship is discussed further, in a general way, on pages 92–5.

THE *CLIFFORTIA PAUCISTAMINEA* AND *ERICA BROWNLEEAE* COMMUNITIES

CHARACTERISTICS AND REQUIREMENTS

The detailed description of *Cliffortia paucistaminea* is to be found in the monograph by Weimarck (1934, pp. 64–5). It is a compact dark green bush growing to a height of 5 or 6 feet and bearing crowded half-inch needle leaves. In quantity it does not at Keiskammahoek extend below an altitude of 4000 feet; above 4000 feet there is no altitudinal limit to it in the district for it grows in profusion up to the peaks of the Hogsback (6360 feet). It has not been seen in the Somerset East or Graaff-Reinet mountains but is common on the Kaga range north of Bedford (photograph 36). It has been recorded only from the Cape Province, Basutoland and Natal, between George in the west and Nkandhla in the east. *Cliffortia linearifolia* extends from George to Inyanga, Southern Rhodesia, and in the eastern Cape at any rate is never dominant above 4000 feet. It is interesting that the local altitudinal relation between these two Cliffortia communities should have a parallel in their latitudinal distribution. Possibly *Cliffortia paucistaminea* is better suited to low temperatures than *Cliffortia linearifolia.*

Erica brownleeae is decribed in Vol. 4, Part I of the *Flora Capensis*. It is a bush less branched and less leafy than Cliffortia and of more upright growth. In localities which suit it, it can reach a height of 12 feet, as may be seen at Evelyn Valley. Except for odd plants which may be found as low as 3500 feet, it is a mountain species with altitudinal requirements coinciding with those of *Cliffortia paucistaminea*. In its distribution it seems limited to the mountains between Katberg and Stutterheim. I have found it growing nowhere else, not even in places where the climate and the vegetation suggest that the conditions for it would be ideal. Two outliers have been recorded by other collectors: Rattray No. 414 in the herbarium of the Albany Museum, from "East London", and MacOwan No. 1260 from "mountains near Grahamstown". Since the locality of Rattray's specimen is not precise, there is little hope of checking the validity of his record. MacOwan's record cannot be relied on, for there are two separate species under his number 1260—*Erica brownleeae* and *Erica calycina*, in the Bolus Herbarium and at Kew respectively. His number is quoted under both in the *Flora Capensis*, in Vol. 4, Part I, pages 251 and 294.

The highland macchia grows best on the south-facing mountain slopes (photographs 38, 52, and Figure 7), a dark green covering which from a distance looks easy to walk through, and lends to the most rugged country a deceptively soft and even appearance. Dense stands of *Cliffortia paucistaminea* grow into an interlacing mass which is for practical purposes impenetrable to people or to stock. Even when the plants are immature and only a few feet high, they cause acute discomfort to anyone walking through them because of the irritation set up by their mucronate leaflets which lodge in the clothes and afterwards work through to the skin. The discomfort is intensified with the height and density of the plants, and often added to by the several species of Rubus which thrive in these highlands. Below the canopy the accumulation of old dead growth forms a jagged lattice-work strong enough to make very rough going. Erica leaves are not mucronate and thus do not cause so much irritation as those of Cliffortia; other than this there is nothing to choose between these plants in the matter of obstructing the movement of stock or people.

Cliffortia is thicker on the slopes than on the flats or ridges and appears more sensitive to drought and heat than *Erica brownleeae*. There are often alternating communities of these two species in consequence, Erica occupying the exposed features and Cliffortia keeping more to the dips and rocky ground, but where there are no clear-cut differences in the habitat, Cliffortia and Erica may be intimately mingled. On the whole, the ground dominated by the highland macchia is shared more or less equally between the two.

Erica seedlings are tolerant of all but the deepest shade, such as is found in forest patches and in the densest thickets of their own community. Elsewhere in the highlands, between and including the extremes presented by thick grass and bare ground, they grow in the greatest plenty, nor is there any perceptible difference between their behaviour and that of Cliffortia seedlings. Mature bushes also are killed by deep shade, as is shown in the pine plantations of Chatha Forest Station. Some of the young pines, planted where there was macchia growing, have now grown above it, and none of the macchia remains alive. Measurements made by means of a General Electric exposure meter indicated that the ratio of the light intensity in the open to that in the pine plantation was approximately 300 to 1. As seedlings of indigenous forest trees are making good growth under the pines, one may infer that it is not lack of water that killed the macchia, which is a more xeric formation than forest (see page 74).

Subject to the provision against excessive disturbance, which is discussed under Ornithogalum (page 109), both species show a tendency to become established more easily in places where the grass cover has been removed or weakened. This is noticeable along old cattle paths, gullies, areas heavily trampled, firebreaks and the like, and is shown in photographs 39 and 40. Another example may be seen in the ministerial grazing on Chatha East. The centre of this camp is pure grassland, sandwiched between two areas of macchia. It is significant that the macchia adjoins the two entrances to the camp, and that the grassland is further away from them. There are probably four favourable influences in such places, firstly a brighter light, the effects of which have already been discussed, secondly a better supply of soil moisture, the effects of which are shown in photograph 41, thirdly less carbon dioxide in the soil air (page 29) and fourthly protection from annual grass fires (page 90). Once the macchia becomes established it rapidly shades out the plants which formerly possessed the area. Grass tufts turn unhealthy and die away to leave etiolated wisps, and a few non-grasses, commonly *Hydrocotyle asiatica*, *Hypochoeris radicata* and *Alepidea* sp., make up the remainder of the scanty undergrowth. There is no stock feed worth considering except the macchia itself, wherever it is dominant and mature (see Table 32).

PROPAGATION

Cliffortia has been seen in full flower as late in the season as March, but most of the flowering takes place in mid-summer. The unisexual flowers, scattered along the branches, are wind-pollinated. Ripe seeds may be found at any time during the winter. They are not easy to collect in quantity because they are shed soon after they have ripened, but enough were obtained for preliminary tests in the laboratory, which indicated that they have a germination of 40 per cent at 70°F, the germination time varying from three weeks to three months. In their natural habitat, seedlings of all stages may be found in abundance throughout the year wherever the light is adequate. This has been discussed in more detail above. The leaves of the seedlings and coppice shoots are broad and soft, and quite different in appearance and texture from those of the mature plants, which Weimarck (1934, p. 169) describes as *pinoid* (see photograph 43). The juvenile form supports Weimarck's view that "the pinoid type of leaf has originated simply by an intense reduction in the width of the lamina . . ." Erica plants from 18 inches upwards may be found in full flower from October to February. They are insect-pollinated and the seeds ripen during the winter, mostly in May and June. They are about half the size

TABLE 32

PER CENT BASAL COVER

CHATHA WEST MINISTERIAL GRAZING

Dense Macchia (one quadrat of one square metre)

Non-grasses		*Grasses*	
Berkheya setifera	1	Unidentifiable	8
Erica brownleeae	142		
Helichrysum sp.	6		
Oxalis sp.	1		
Pteridium aquilinum	2		
Unidentifiable	4		
	156		8

Total basal cover 1·64 per cent.

Adjoining Grassland (three quadrats of one square metre)

Non-grasses		*Grasses*	
Berkheya setifera	5	*Andropogon appendiculatus*	408
Cliffortia paucistaminea	184	*Aristida galpinii*	27
Erica brownleeae	23	*Elyonurus argenteus*	316
Helichrysum argyrophyllum	133	*Harpechloa falx*	626
Legume	2	*Panicum ecklonii*	50
Pteridium aquilinum	16	*Sporobolus centrifugus*	10
Sedge	82	*Themeda triandra*	1267
Unidentifiable	14	*Trachypogon capensis*	130
		Tristachya hispida	31
	459		2865

Total basal cover 3324/300—11·08 per cent.

of a pinhead and average twelve to a flower, varying from five to twenty-two. Laboratory tests indicate that with a temperature more or less constant at 70°F, the germination is about 23 per cent. The first seeds begin germinating after three weeks and germination may continue for 4 months or longer. Although it has a lower germination than *Cliffortia paucistaminea*, what it lacks in this respect is more than made up by the quantity of seed it produces. Both species of Cliffortia have unisexual flowers (Weimarck, 1934, pp. 53, 65) and each female flower bears only one seed (Weimarck, 1934, p. 34). There appears to be no great difference in the numbers of flowers borne by Erica and Cliffortia. On the assumption therefore that they produce an equal number (x), the number of seeds produced would be as follows:—

Erica 12x

Cliffortia x/2.

That is, Erica produces twenty-four times the amount of seed produced by Cliffortia.

EFFECTS OF GRAZING

Cliffortia paucistaminea is grazed by stock, but reluctantly. The remarks on the checking of *Cliffortia linearifolia* by rotational grazing apply here as well, but control will be a more difficult matter because *Cliffortia paucistaminea* appears considerably less palatable than *Cliffortia linearifolia*. Erica is rarely eaten by stock. Even in times of great scarcity, signs of browsing in this community are the exception, and are limited to what are apparently nothing more than tentative mouthfuls here and there. It is hence very unlikely that Erica could be kept in check by controlled grazing alone in the parts where it is now growing. Further remarks on grazing are given on pages 86 and 91.

EFFECTS OF BURNING

As the macchia matures, the lowest branches become cut off to a certain extent from the light and tend to die back, forming a gradual accumulation of dead wood at the base of every bush. Leaves, dead twigs, flowers and seeds, as they are shed, gravitate downwards, some being trapped on the way by the lower branches and some falling through to the ground, where they become matted and caked into a dense layer sometimes several inches in thickness. The density of the macchia shields this trash from dispersal by wind and rain and animals, and decomposition is relatively slow. The result is that all but the youngest macchia grows on a deep foundation of inflammable material. An examination of the green branches of Cliffortia shows that they also bear inflammable material—an encrustation of dead tissue made up of the basal parts of the leaves, which persist after the disarticulation of the laminae. The matter is discussed by Weimarck (1934, p. 166). Its density and height, and its production of dry matter make the macchia easily the greatest fire hazard in the district. Fortunately it is kept wet for a large part of the year by the high rainfall, mists, and winter snow, which make the risk of fire less than it would be in the drier climate of the lowlands. Even on the mountains, however, dry spells do occur, and it is indeed only a matter of time before a fire breaks out and consumes any given area of macchia. As the growth is densest on the slopes, the draught which is always produced by the rising of the heated air is a strong force in augmenting a macchia fire (see page 116). An army of beaters is helpless against any that is well-established, and counter-burning is the only possible way of stopping it. The most furious fires are those that break out when high winds are blowing. They are an unforgettable sight, and almost impossible to control, for the strength of the wind may be such that firebrands are torn from the bushes and sent sailing across country to start fresh outbreaks ahead of the main fire. On 26th August 1936 one started during a high wind somewhere near the headwaters of the Wolf River, travelling eastwards along the mountains as far as the eastern corner of the Eseka Forest. Mr. Harry Hunter, at that time forester at Chatha, saw its whole progress and states that firebrands were blown from the plantations across the valley to Chulu Ridge, a distance of about a mile and a half, and that they set one of the stock kraals alight near the northernmost group of huts on the ridge. Charred sticks were picked up at St. Matthews, 5 miles away.

The regrowth from this macchia was considerable again in 1942, but not sufficiently so to be burnt as it stood, for when Sonntag's experimental plot was laid out in that year, the macchia had to be cut down and dried before it could be burnt. By 1948, however, its density and maturity were such that it was again in a dangerously inflammable state, and on 8th September 1948 another fire, supported by a strong wind, sprang up in the Chatha West ministerial grazing. Its course was very similar to the one which had preceded it. It jumped the firebreaks with equal success, and in a short while had laid waste nearly all the exotic plantations in the Chatha basin, and nearly all the country above them.

Except for islands of vegetation which somehow escape being burnt, the transformation of the countryside after such a burn could hardly be more complete (photograph 42). Most side branches are burnt away to leave only main stems standing, and macchia areas formerly impenetrable may be crossed reasonably easily. A deep ash lines each dip and covers the streams with a blackened greasy scum. Rocks and stones of all sizes show fresh spalling, and projecting bits of earth like worm castings and molehills are baked hard and red, but ground which is even does not appear to be much affected, and the fact that the grasses almost invariably shoot again shows that their roots remain unharmed. Further evidence that the soil is heated only superficially

is provided by new molehills and worm castings which are soon thrown up again. In this connection the temperatures recorded by Cook (1939) for grass fires are of interest. She found that although the temperatures above ground were high (over 600°C) there was little rise in soil temperature even at a depth of 2 inches.

The mummified body of an occasional lizard or snake may be seen, but rarely. Probably most of these animals receive sufficient warning to escape into holes or under the shelter of rocks. Of insect life no sign remains. The macchia is killed almost completely and nearly all the regrowth is from seedlings. The time taken for them to appear is probably dependant on weather conditions. One month after the fire of 8th September 1948, seedlings of grasses and *Hypoxis*, *Berkheya*, *Helichrysum* and *Scabiosa* spp. could be identified, but none of the macchia were to be found. Two months after the fire there were many more seedlings of these and other species, but still none of macchia. They were seen for the first time on 29th December 1948, and from then onwards countless new ones came up. It was noticeable that they were scarce where the macchia had been dense, and abundant where it had been sparse. The reason is probably that the dense macchia gives a burn hot enough to destroy most of the seed, for apart from the flames which envelop the bushes themselves, there is a slower fire which, fed from the litter on the soil surface, continues burning long after the blaze is over, and as far as the seeds are concerned is likely to be the more effective destroyer. As there are few plants that live in the weak light under thick macchia (page 82), a fire will leave such areas practically bare, and they remain so until seeds come in from neighbouring areas. After the September burn quoted in this paragraph, there were tracts of several morgen with an exceedingly scanty cover, and that consisting mainly of *Pteridium aquilinum* and *Rubus* spp., both economically useless plants. Parts up to eight square yards in area were destitute of any form of vegetation.

Heat appears to have a depressing effect on the germination of Erica seeds, as was indicated by the following test:—Four hundred seeds were sown on dry soil in a flowerpot and lightly covered with sand, then dry grass was heaped over the surface to a depth of six inches and set alight. The soil was kept continually moist after the initial watering two days after the burn. On the twenty-sixth day after watering was begun the first seedlings germinated, thereafter germination to a total of twenty-seven seedlings continued slowly for four months. A control batch behaved in a similar way except that the total number of seedlings was forty-nine. It is probable therefore that the rapid regeneration of Erica after a fire is in spite of the fire and not because of it. It has not yet been possible to test the reaction of Cliffortia seed.

In Cliffortia, regeneration from suckers may take place if the fire is mild (photograph 43), but this is rare, and coppice shoots from the base of the stem are commoner. Bushes which are merely signed will sprout again from the above-ground parts. Erica seems more sensitive to burning, because regeneration by suckers or coppice shoots has so far not been noted. With fires of less intensity the damage to Erica is patchy. The lower branches, with their accumulation of dead growth, are more vulnerable, and the higher greener ones usually escape. Such lightly burnt bushes are consequently more spindly, and have in addition a characteristic mottled appearance from the mixture of dead and healthy branches in them.

SUCCESSION

Evidence From Protected Areas

If areas of highland sourveld are protected from fire and grazing, the indications are that they change to macchia. The plot established by Schonland in September 1923 is an example. In his account of the experiment (Schonland, 1927, pp. 8–9) he states that this plot was under grass in 1926, which statement is proved by photograph 45, taken at this time. There had been a spectacular change from Helichrysum to grass under his treatment, and he makes it clear in his summary (page 9) that he regards the original condition of these parts as "pasture ground covered chiefly by Rooigras". In this he is probably mistaken, as will be shown (see page 111). I have it on the authority of Dyer, who worked with Schonland, that *Cliffortia paucistaminea* and *Erica brownleeae* were originally absent from the plot. This is confirmed by the list of plants given in the appendix to Schonland's paper, and by photographs 44, 45 and 53. *Cliffortia linearifolia* was recorded, but has no significance at this altitude, which is 4100 feet (see page 77). Schonland is in error in giving the altitude as approximately 3000 feet on page 5 of his report.

The fence around the plot remained in place until March 1947. Towards the end it fell into disrepair, but for most of this period the plot was protected from uncontrolled grazing and stock was allowed in under supervision only—conditions ideally suited to the maintenance of a vigorous grass cover (Weaver and Clements, 1929, p. 392; Bews, 1921, p. 69; Story, 1939, p. 337; Henkel, 1947). A setback to any macchia that may have become established there was the burning of the plot on 8th July 1930, and again on 26th August 1931. Reports on these fires are in file V 2/2 of the Botanical Survey, Grahamstown. With the first fire "the plot was *completely burnt off*. Although it was only intended to burn a portion, the wind changed during operations, and the fire was completely out of control within a few minutes owing to the dense growth". The second burn was also complete, and took place during a high wind. I was fortunate enough to see the plot in September 1947, while some traces of its former vegetation still remained, and was struck by the amount of macchia which had grown within its boundaries, in spite of the circumstances just mentioned (see photographs 46–7). A count established that there were 131 bushes to the acre, both Cliffortia and Erica being represented. The bushes were up to 6 feet in height. Outside the borders of the plot they averaged 25 to the acre. A diagram of the counts is given in Figure 7. This is a very heavily grazed area and the note on excessive disturbance, page 109, applies here.

The plot has thus yielded information in excess of anything which Schonland could foresee, and, in a district everywhere exposed to uncontrolled grazing, exceedingly difficult to obtain. In terms of a clause in the original agreement entered into between Schonland and its Native owners (Schonland, 1923), the experimental ground was restored to them when the experiment was discontinued. But for that unfortunate clause, the district would have been richer by a plot which would have continued yielding interesting and valuable results. It has shown that Helichrysum gives way to grass, and grass to macchia. Problems that remain unsolved are the time taken for the macchia to become dominant, its final density, whether it is stable or whether it is in turn replaced by some other form of vegetation, and the respective rates of increase of Cliffortia and Erica. The plot was of particular interest because it was laid out on the northern slopes, which are much less readily invaded by macchia than those facing south.

The aerial photographs of 1938 and the photographs taken by White in 1948 show a clear and striking boundary between the surrounding Helichrysum and the grass on the experimental ground. The destruction since the fence was removed has been sudden and complete. Under the onslaught of the hungry stock converging from all sides upon it, the cover has reverted to Helichrysum so extensively that except for a faint line on the south side, the boundaries of the plot are imperceptible in the aerial photographs of 1950, and almost so if an inspection is made on foot. The macchia has been chopped down, sometimes to be used for rough brushwood sledges and sometimes apparently in a mere spirit of idleness. When fenced, the plot meant so much to the student and so

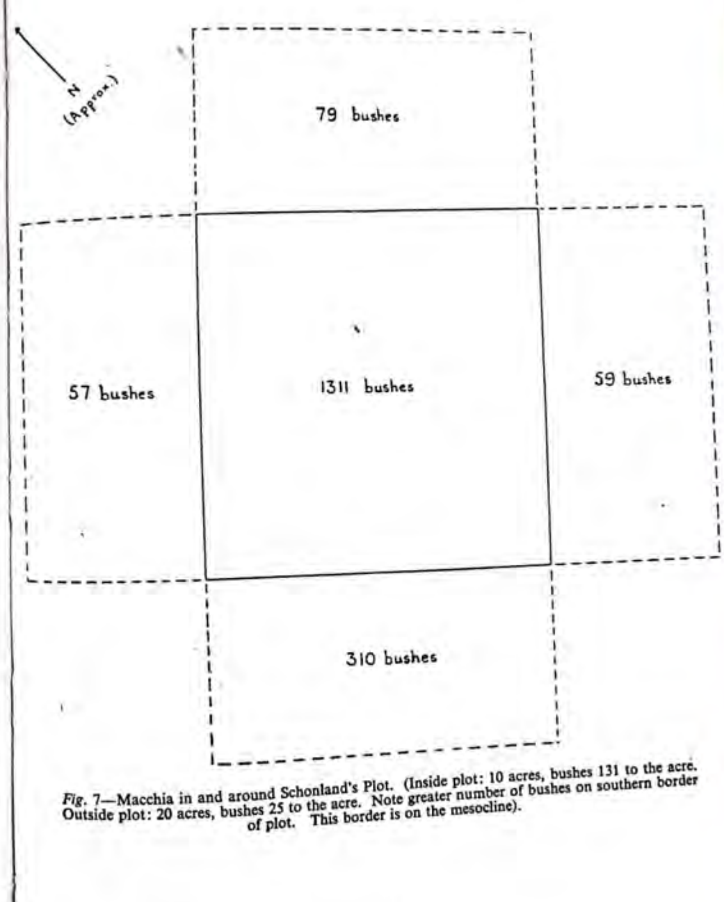

Fig. 7—Macchia in and around Schonland's Plot. (Inside plot: 10 acres, bushes 131 to the acre. Outside plot: 20 acres, bushes 25 to the acre. Note greater number of bushes on southern border of plot. This border is on the mesocline).

little to the Natives in terms of grazing that one can regard its ruin only as a matter of the greatest regret.

Mr. A. E. Sonntag and Mr. Harry Hunter have kindly given me information on the history of another experimental plot, in area half an acre, which was laid out at an altitude of 4700 feet in the south-facing macchia north of Chatha Forest Station. The enclosed macchia having been cut down and burnt where it lay, the plot was left undisturbed except for the cutting of six bags of grass in October 1947. The following is a summary of the report dated 8th January 1948 of Forester Harry Hunter:—

> "First year—fynbos and various grasses showed up slightly, but there was very little vegetation.
>
> Second year—grasses began to cover the whole area and fynbos was suppressed.
>
> Third year—the plot was well grassed, the fynbos scattered but coming through and 12–18 inches high.
>
> Fourth year—restored to very excellent grazing, scattered fynbos 2–3 feet high."

In the fourth year, the dense stands of Erica and Cliffortia, 5 to 7 feet high, gave the surroundings an appearance strikingly different from that of the plot itself, which had an excellent grass cover with only a little macchia apparent. However, a more careful examination established that macchia seedlings in it were numerous everywhere. Three belt transects of 90 square metres each were done in October 1947, and showed that the average number to the square metre was 14·4, that is, over 60,000 plants to the acre, and in number up to 52 to the square metre. They were growing without discrimination in the centres of tufts and between them, Erica predominating. Their vigour and the number well established left little room for doubt that they would in time cover the plot again and shade the grass out of existence. They were prevented from doing so by the fire of 8th September 1948 (described on page 84), which killed them root and branch and at the same time gave the grass an added advantage by stimulating it into luxuriant new growth. In spite of this setback, young seedlings, again coming up in their thousands, show that the macchia will inevitably oust even this abundant grass.

An interesting example of the development of macchia on a hilltop near Evelyn Valley Forest Station is recorded in the files of the Trigonometrical Survey, Kingwilliamstown. The record is by H. A. Ruddock, headed *Report on Tertiary Recce: Area* 32/37 *MP* 14 *King William's Town* and dated 4th August 1946. I am indebted to Mr. Ruddock for drawing my attention to this report and for allowing me to make the following extract:—

> "I found 91 WEST PEAK PIRIE completely smothered in extremely dense, rank, almost impenetrable vegetation, fifteen feet high and in places higher. I spent the whole day, with my Native assistant, clearing a few lanes to verify certain essential rays to the east. It was obvious that for rays to the south and west, at least one auxiliary station would have to be established, but as it was impossible to force one's way through the vegetation to the edge of the krantz, I had to leave this until later."

According to Mr. J. P. Roux, then forester at Evelyn Valley, the part round this beacon had not been grazed for many years. It was erected in 1912, at an altitude of 4184 feet. Copies of photographs of the beacon, taken in 1912, 1942 and 1947, were kindly given by the Director, Trigonometrical Survey. They are not clear enough for reproduction, but, as might safely be taken for granted, the earliest one gives an uninterrupted view of the horizon, and shows that the beacon in those days was prominent and exposed. The Director's minute states: "In 1912 there appears to be no vegetation in the vicinity of the beacon".

A fourth protected area exists by virtue of its inaccessibility. It is at an altitude of just under 6000 feet, and is situated half-way down the western cliffs of the mountain known locally as Chatha Peak, and shown on the Department of Irrigation map (1936) as Gxulu Mountain. To avoid confusion, the Native name Geju is used on the vegetation map which accompanies this paper. As a dark patch against the rock, this area is visible from many miles away. An examination through the field-glasses and by means of the aerial photographs showed that there was little likelihood that stock could reach it, and this was confirmed later when three separate attempts were made to visit this place on foot, all without success. At the fourth attempt, a way was found from the cliffs above, an easy climb but out of the question for stock.

The ledge is about 8 morgen in extent, sloping steeply to the west and bearing a thin, rocky soil. There is a little grass combined with a wealth of herbaceous plants round the edges of the macchia, but elsewhere it is seldom to be found, and apart from insignificant exceptions, macchia is dominant throughout. It is about 6 feet high, and is for the most part made up of Erica, Cliffortia being uncommon and confined more or less to the rockiest parts. *Protea lacticolor* is plentiful, and a few stunted specimens of *Kiggelaria africana* and *Buddleja salvifolia* are present. No other trees were seen. The ledge is not entirely cut off from animals. Roving troops of baboons forage through it and there is a permanent and large population of dassies and rodents to browse the vegetation. Sparse, and overgrown with a number of species of Helichrysum, a shorter growth of macchia over about half a morgen near the southern end shows unmistakable signs of having been burnt. Other than this, there are no traces of burning, and the bare encircling cliffs make it extremely unlikely that fire is anything more than a rarity brought in by a chance firebrand (see page 84).

If grass were the climax in the highlands above the forests, it would be difficult to find an explanation for the macchia on this protected terrace. The view that the grass may have been destroyed by dassies is not tenable, otherwise it would be destroyed also in the places where it is now growing. Moreover, dassies could be expected to suppress the macchia at least as much as the grass, for their food consists chiefly of the young shoots of shrubs (Sclater, 1900, p. 313). The run-off from the cliffs above must supply the terrace with water additional to that obtained from the rain which falls directly upon it. This probably favours macchia, but observations from the other protected parts, Schonland's plot especially, show that it would not be a decisive influence.

The evidence so far presented suggests strongly that the climax vegetation above the present timber-line and as far as the crests of the mountains is macchia. Certain anomalies remain to be discussed.

Historical Evidence

Mr. W. M. Spring has lived at Keiskammahoek for over 80 years. He states that when he was a boy he used to traverse the Amatole highlands on foot, sometimes sleeping out and not returning to the village for days at a time. Plainly Mr. Spring is unlikely to be wrong in his statement that the highland veld in those days consisted entirely of open grassland, and that macchia was absent. Confirmation may be had from any of the older generation, members of the public and officials of the Forestry Department alike, who knew the Amatole Mountains during the last century or in the early days of this. Mr. A. Köpke, at one time forester at Chatha Forest Station, can recall the Native cattle posts on the macchia slopes near the top of the present right-of-way west of the forester's house, in country exactly as described by Mr. Spring. Mr. E. B. Dwyer, formerly District Forest Officer, is quoted by Schonland (1927, p. 6) as follows:—

"I was stationed at Keiskama Hoek from 1889 to 1893, and the areas now affected" (by Helichrysum) "were then stretches of waving roo grass in autumn, and the paths up from Mnyameni to the ground behind were scarcely visible from below."

In an address read at the Queen's Jubilee Exhibition, Grahamstown, in 1887, Mr. D. E. Hutchins, then Conservator at Kingwilliamstown, states:—

> "Above the natural forests on the Amatola and Pirie ranges are extensive tracts of waste mountain land, yielding at present nothing but a coarse grass which burns annually in fierce fires and is every winter a source of anxiety to those in charge of the forest below."

DISCUSSION

History shows indisputably that the Amatole mountain veld was formerly under grass, yet the botanical evidence is that the climax community is macchia. These two apparently contradictory views may be reconciled by a consideration of one important point mentioned by Hutchins, and itself a matter of history: *annual fierce fires*. They are the surest force in checking the spread of macchia and their influence in establishing a grassland sub-climax has been demonstrated locally in the plot laid out by Sonntag and Hunter, and is shown in photographs 48, 49 and 51. Similar cases with various other types of scrub and grassland are reported by Bews (1929, pp. 294, 296); Rowland and Hector (1932, p. 324); J. Phillips (1935a, p. 238; 1935b, p. 58) and Michelmore (1939, p. 305). In a specific reference to macchia, J. Phillips (1930, p. 335) states that fire "reduces the seldom abundant grass". His observations and those of the authors cited by him, however, refer only to the western Cape, where the climate, according to Schimper's classification (Schimper, 1903, pp. 173–4), is unsuited to grasslands and where circumstances may accordingly be different.

A reconstruction of the possible chain of events which has determined the composition of the Amatole vegetation of the present day is as follows:— The mountain slopes above the forests were originally under macchia as tall and dense as any to be found today. At some time in South Africa's prehistory, man started firing the slopes. Little by little, as the macchia became sparser and as its stocks of seed were depleted, the fire-resistant grasslands obtained a footing, and spread, until the macchia was confined to the sheltered ground among rocks and along ravines where the fires could not easily penetrate. With moderate grazing and frequent fires these grasslands remained stable, and it was at this point that the mountains were first known to Europeans and the nature of the vegetation recorded. Proportionately to the establishment of settled conditions, the population increased, and with it the numbers of stock. The grasslands were cropped short and fires became weaker and less fequent. Macchia began migrating out from its strongholds, the patches linked, and within a relatively short period after the founding of Keiskammahoek, in the neighbourhood of 60 years, it had re-established itself over much of its former home. It is rare indeed for the succession to be hastened by disturbances caused by man or his stock, so much so that Bews (1931, p. 7) has given it as his opinion that "man's interference always tends to send back the plant succession". But this is not an invariable rule, as the behaviour of the macchia shows, and as do other examples given by Phillips (1935a, p. 239) and Weaver and Clements (1929, p. 408).

The time taken for grassland or Helichrysum areas to change to macchia, although dependant mainly on the supplies of macchia seed present, varies also according to competition from the grasses and according to the aspect, as shown in photographs 38–9. It is understandable then that it is not possible to forecast times with any accuracy, and the few examples to be quoted do no more than give a very incomplete picture of the speed of succession with uncontrolled grazing. Photographs 50–1 show that even where there are alternes of Helichrysum, grass and macchia, little change may be expected in their relative

proportions within six years. This has been confirmed by other dated photographstaken in the Chatha West ministerial grazing. They are not suitable for reproduction.

A comparison after a period of 12 years is provided by the two sets of aerial photographs, taken respectively in 1938 and 1950. They show that this interval is enough to allow appreciable amounts of macchia to invade parts previously bare, or spread in parts where it was previously thin, and to form a community dominating between 20 and 50 per cent of the area. From these examples one may conclude that the increase of macchia under present conditions of grazing is generally inconsiderable in under six years but considerable after twelve.

Twelve years may be long enough to allow a marked spreading of the macchia even in protected areas. This has occurred on the plateau overlooking the Maden Dam from the north-west, in the protected catchment area at Evelyn Valley Forest Station, and may be seen at a glance from the two sets of aerial photographs. That the process is relatively slow, however, is shown by the fact that the spread is even more marked in the area adjacent and to the west, which is subjected to uncontrolled grazing by Native stock.

Examples from a third area will show how conditions may vary within a radius of a few hundred yards. Schonland's plot, clear of macchia in 1931, on a northern aspect and with sources of seed two or three hundred yards away, had after 18 years accumulated 131 bushes to the acre, or one to 38 square yards—a striking concentration by comparison with the immediate surroundings (see page 86 and Figure 7). The immediate surroundings are Native commonage and are subjected to very heavy grazing by all kinds of stock, including goats, which are not permitted in the ministerial grazing. In addition, the aspect is a hot one. Judging by the present bareness of the area, these two influences are a combination which may be expected to keep the land clear of macchia indefinitely. Slightly to the south the aspect is favourable, and here the macchia can successfully overcome the one remaining influence of heavy grazing. Photographs 52–3 show clearly how it has done this since 1926.

This small area shows then that heavy grazing and a hot aspect inhibit the growth of macchia almost entirely, controlled grazing and a hot aspect allow a slow increase of macchia, and heavy grazing and a cool aspect allow a rapid increase.

It is at present vain to speculate on the age when the macchia was originally dominant on the Amatole Mountains. Certainly man was present in the district long before the Bantu arrived, for middle stone age implements now stored at the Albany Museum have been collected on Mount McDonald, and Bushman implements near Middledrift, by Hewitt and Stapleton, but whether early man regularly employed fire in his hunting activities on the mountains is unknown. He could easily have done so. When conditions are favourable, no more than a spark is necessary to clear away areas of macchia which an army could not otherwise destroy. Prof. M. Wilson, of the Department of Social Anthropology at Rhodes University, considers that prehistoric hunting fires were very probable, and, in support of her view, states that fires started by the present-day Bushmen are a cause of friction between them and their cattle-owning Bantu neighbours.

It is doubtful whether fires arising from natural causes before man reached these parts would have occurred sufficiently often to keep the vegetation at the grassland stage. Natural fires are mentioned by J. Phillips (1930, p. 352), who does not comment on their possible frequency, and by Clements (1916, p. 57). Referring to Idaho and Montana, regions of frequent dry thunderstorms, he states "the number of such cases would appear to be large". He does not, however, give any figures to support his statement. One took place recently in the Tarka district when the southern of the two flat-topped hills Mary and

Martha was struck by lightning. This started a fire which swept the whole plateau, and is the only authenticated case known to me, apart from the firing of a single tree during a storm in the Hogsback forests which has been reported by Prof. M. Wilson. From the lack of other specific instances, such fires, in the Cape at least, appear rare, and because regeneration of macchia from seed is good, it is not rare fires that prevent its establishment, but frequent fires.

Grass is never totally absent from the climax macchia (page 103, paragraph 1), and as well as scattered individual grasses there are the larger communities discussed in Chapter 4. It does not have to migrate in from another formation and it is thus not difficult to account for its presence once the macchia has been destroyed.

POST-CLIMAX STAGES

In the opinion of some workers, the macchia in the sourveld is merely a stage towards a forest climax, probably not high forest as found below the present timber-line, but something taller and more robust than the macchia. The following observations support this postulation:—

1. *Buddleja salvifolia* was recorded from Schonland's plot between 1923 and 1926, and specimens were still present in 1949. They were found scattered through the Helichrysum outside the plot as well. A single specimen of *Halleria lucida*, not recorded by Schonland, was growing in the plot in 1949.

2. Occasionally, high exposed parts support trees in some quantity, as may be seen 16 miles from Keiskammahoek on the road to Stutterheim. Rare stunted specimens of *Podocarpus latifolius* are found along the peaks of the Amatole range, and isolated trees of other species occur sporadically in the bleakest sites. The following is a list of those so far found:—

Bowkeria sp.	*Halleria lucida*
Buddleja auriculata	*Heteromorpha* sp.
Buddleja salvifolia	*Kiggelaria africana*
Canthium ciliatum	*Myrica* sp.
Cassine kraussiana	*Osyris compressa*
Cassine tetragona	*Podocarpus latifolius*
Cussonia paniculata	*Rapanea melanophloeos*
Euclea undulata	*Rhamnus prinoides*
Gymnosporia acuminata	*Rhus dentata*
Gymnosporia buxifolia	*Rhus pyroides.*

At 4000 feet, thickets of some of these species have developed in the forest reserve in the Kaga Mountains north of Bedford. Although they occur in places not so well sheltered as those under forest, they are absent from those most exposed. The trees forming the thickets at Bedford are:—

Buddleja auriculata	*Heteromorpha* sp.
Buddleja salvifolia	*Leucosidea sericea*
Cassinopsis ilicifolia	*Pittosporum viridiflorum*
Grewia occidentalis	*Rhamnus prinoides*
Gymnosporia buxifolia	*Rhus* spp.

There are dense patches of bush overgrown with *Clematis* sp. and alternating with glades in which *Cymbopogon marginatus* is dominant. *Cluytia affinis*, *Cluytia pulchella* and the scrambling *Helichrysum petiolatum* are among the commonest plants in the matted growth of herbs and undershrubs. A similar community grows at an altitude of about 4500 feet on a terrace on the western slopes of the range north of Seymour, about a mile north-west of point 5106. (Reference map S.A. 1: 500,000

Sheet Queenstown SE 33/26). It occupies the same type of position, intermediate between the exposed high ground and the sheltered forest belt. At Evelyn Valley is another example, growing in the folds of the catchment area above the indigenous forests. The altitude is about 3500 feet.

3. Slopes of talus above the Amatole forests are often under flourishing communities of trees, sometimes a mile or more from their nearest neighbours. The Chatha area has several of these isolated tree patches, and others occur on the farm Coolin, on the south slopes of the Elandsberg, up to about 6000 feet. Those on Coolin, being the largest and the furthest from the forests, are of particular interest. The scree is made up of a confusion of angular rocks, between a few cubic feet and several cubic yards in volume. With the possble exception of goats, stock cannot walk across them, and when fencing, farmers here and elsewhere sometimes are able to turn this to advantage by using them as natural barriers, linking them with lengths of fencing and thus saving considerable amounts of material. Some patches of trees grow in the middle of the scree, but most by far keep faithfully to its edges and form a hedge all around it from two to fifteen yards in thickness (see photograph 54). The trees comprising it are:—

Bowkeria sp.	*Halleria lucida*
Buddleja auriculata	*Heteromorpha* sp.
Buddleja salvifolia	*Kiggelaria africana*
Euclea undulata	*Rhamnus prinoides*
Gymnosporia acuminata	*Rhus pyroides.*

4. Various species of pines, gums and wattles, self-sown, grow freely in the highlands up to and over 5000 feet above sea level (photograph 37), and small plantations of poplars in the Kaga Mountains north of Bedford likewise, at 5000 feet.

The examples mentioned all indicate that trees can grow in the highlands, and therefore that macchia may be a seral community, but they require a certain amount of qualification.

The forest on the road between Keiskammahoek and Stutterheim is at an altitude of only a little over 3000 feet, and thus below the zone in question, in a region of milder temperatures. The Buddleja and Halleria in Schonland's plot, the other indigenous trees scattered over the highlands, and the thickets on the Katberg, on the Kaga Mountains and at Evelyn Valley cannot be so easily dismissed. Singly these examples might with a certain amount of justification be regarded as exceptions, together they make it plain that a type of vegetation sucessionally more advanced than the macchia may be able to grow above the forests. A significant point is that the thickets are always in shelter. The individuals in exposed or high places do not give any indication that they are on the increase, as may be seen from those in Schonland's plot, and in the protected area on Geju Mountain, nor do the indigenous trees which clothe the lower slopes of the Hogsback at King's Nek show any sign of extending further towards the summit. They are found in a belt along the lower slopes only. Had they once covered the whole mountain side, there would be no apparent reason for their present absence from the upper parts of it, for the slope is even and the soil uniform.

Poplars and many other exotic trees can largely avoid the rigours of the winter by casting their leaves (Hutchins, 1887). This reduces their water-loss and enables them to withstand the physiological drought which can at times prevail in the highlands, and which is discussed in Chapter 4. This adaptation to drought has been noted also by Rawitscher (1948, pp. 255–8), who reports that the deeper-rooted plants in the drier areas of Brazil reach the water-table and are evergreen, the shallow-rooted ones being deciduous in the dry season. Nearly all of our indigenous forest trees are evergreen and hence do not possess this means of enduring drought. Hutchins states that we have only three which are deciduous, those he has in mind being probably *Celtis kraussiana, Calodendrum capense* and *Rhus legati.*

The tolerance of wattles is apparent from a paper by Wood (1934, pp. 71, 85) in which he mentions the frequency of the phyllode-bearing Acacia species in the 8-inch rainfall zone of Australia, and states that this type of leaf is "characteristic of all climates except that permitting rain-forest development".

Gums as classified as xerophytes by Maximov (1929, p. 284).

Reference to the xerophytic or tolerant nature of particular species of Pinus (*Pinus sylvestris, Pinus ponderosa* and *Pinus montana*) are given by Braun-Blanquet (1932, pp. 142, 267) and Warming and Vahl (1909, pp. 216, 312, 314). That this nature is characteristic of the conifers as a whole is shown by Wells, Huxley and Wells on page 658 of an undated publication in the following statement:—

> "Conifers reappear again polewards of the main temperate zone. The encircle the whole of the northern hemisphere. An almost unbroken belt of them, four hundred to eight hundred miles wide, stretches for over five thousand miles from Scandinavia to the Pacific. In Siberia it is called taiga; but elsewhere, strangely enough, it has earned no special name. And a second huge forest of the same type covers the North American continent from Labrador to Alaska. Sometimes such a forest is all of fir, dense and gloomy; but deciduous trees like birch and alder may break the inhospitable monotony. Firs, however, are the dominants. Yet this does not mean that they find themselves here in the most favourable conditions, for spruce from sub-artic North America grows much larger and better when transplanted to the milder climate of Scotland. It only means that, in the struggle for existence, they can survive where other trees with greater demands fail. They are not in any perfect adjustment with their not very attrative environment, but they are better adjusted than any other trees."

In a paper by Cannon (1914, p. 230) the same view is expressed:—

> "The fitness of the conifers in general to life in high altitudes, where the evaporation rate is great and the absorption of water is retarded by a low temperature . . . is well known."

The tolerant nature of gums and pines may be deduced also from the fact that many of those in plantations above the forests are planted for wind-breaks or as ornamental trees on karroo farms, where most of the indigenous forest trees would have no hope of survival. It is thus evident that the exotics that have been mentioned are better adapted than our indigenous trees to withstanding the physiological winter drought of the highlands, and accordingly their presence does not necessarily give grounds for assuming that the environment is suitable for our native forest trees as well.

Let us suppose that the trees which border the talus slopes are vestiges of a former extensive vegetation which has been destroyed by man. Man could have destroyed the trees only by felling or burning. Felling may be ruled out, for no rational people would have gone to such enormous pains for no obvious purpose, nor would they have eradicated practically every tree and yet left a fringe, perfectly easy of access, round each talus slope. Burning is also out of the question. The bare scree would certainly have given protection from fire to any trees growing away from its edges. The existing ones, however, border it, and would have been in direct contact with the hypothetical ones which were burnt. It follows that the fires which killed the hypothetical ones would have killed the existing ones also. There is a possibility that fires originally made a clean sweep of this whole area, talus slopes included, and that the present trees are a new generation, established on the only places where fire

cannot reach them, and prevented from invading the encircling grasslands because the grasslands in this area are burnt as a matter of routine. Direct evidence to the contrary is lacking, but indirect evidence suggests that this theory is unlikely to be correct. Firstly, a similar relation between scree vegetation and that surrounding it holds good in South Africa even where veld fires are rare or unknown. Examples may be seen two miles east of the road between Cradock and Zwagershoek from a point eleven miles from the railway crossing outside Cradock. Others occur in the Graaff-Reinet district on the slopes of the Tandjesberg. They are visible from the road near Petersburg, about twenty-four miles east of Adendorp in a direct line, and from the main road between Pearston and Graaff-Reinet. Secondly, screes in other parts of the world have been shown to support not a climax community but a post-climax one. Weaver and Clements (1929, p. 477) report ". . . other post-climaxes occur on escarpments, talus slopes and rocky hills from western Texas to Mexico and eastern California." Thirdly, scree on the Alps, where grass-burning is not practised, supports dwarfs shrubs, while "in less steep places, grassland predominates, and higher up, as far as perpetual snow" (Schimper, 1903, p. 775).

The evidence taken as a whole suggests that the macchia may in sheltered places and at the lower altitudes be replaced by the type of low scrub which is under discussion, but that it is nearly everywhere else the climax on the Keiskammahoek highlands.

OTHER COMMUNITIES

Although the extent of the Cliffortia and Erica communities makes them easily the most important constituents of the macchia, there are several other plants common enough to be mentioned specially. They are *Protea lacticolor, Bobartia gracilis, Rubus* spp., *Pteridium aquilinum, Stoebe* spp., *Passerina* spp., *Metalasia muricata* and the communities on the vleis.

RUBUS SPP.

There is a persistent belief that the *Rubus* spp. are all introduced weeds. Rattray's specimen of *Rubus pinnatus* No. 320 for example, collected on the Hogsback in 1920, bears the note "cultivated, but now found in many parts of this altitude". It was, however, collected by Ecklon and Zeyher on the Kat River more than a hundred years ago, and is listed among the indigenous species in the *Flora Capensis*. *Rubus rigidus* is another indigenous one from the district. *Rubus affinis* and *Rubus immixtus*, two more common local species, are not listed in the *Flora Capensis* and are therefore presumably introduced.

All are apt to become prominent in parts subjected to heavy trampling, particularly in conjunction with burning. Their increase with the rate of stocking is evident in the ministerial grazing of Chatha East, directly above the forester's house. The ridges of the buttress slopes descend in a series of slight curves, each of which ends in a more or less horizontal platform at its lower end. Because of the steepness of the slopes, the cattle when they wish to rest come together on these small headlands, which are consequently more severely trampled than the slopes. There is nearly always a growth of Rubus on them, but in the surroundings it is as yet very rarely seen. *Erica brownleeae* is also beginning to invade the headlands, which is in accordance with the observations recorded on page 82.

By burning, Rubus is stimulated into putting out a greatly increased growth of long stout runners radiating from the crown of the main plant, and growing downwards at the tip into a small hook which may take root and become another source of runners. The repetition of burning results at last in an infestation like that shown in Table 33. The figures are from a line transect put across a firebreak east of King's Nek above the indigenous Schwarzwald Forest, Wolf Ridge Forest Reserve. The firebreak is made by clearing two parallel strips through the vegetation and burning what remains between them. So far, the Rubus in the burnt area has increased to nearly five times the amount outside it. These observations agree with those of Sim (1907, p. 216), who notes that "they are among the first ligneous plants to resume occupation after a fire has cleared a forest area . . ." Stent (1925) quotes an Australian paper which advises burning as a method of control, but this is admittedly in conjunction with digging out or ploughing—both impossible to carry out economically over the rugged country which is overgrown with Rubus at the present time. No satisfactory method of eradication has yet been found.

TABLE 33

EFFECT OF BURNING ON GROWTH OF RUBUS

LINE TRANSECT FIGURES

Unburnt area	Periodically burnt area	Unburnt area
38 paces	76 paces	38 paces
7 stems	85 stems	11 stems

Total stems on transect line, burnt area 85
unburnt area .. 18

An interesting fact is that in the catchment area at Evelyn Valley where the same system of burning the firebreaks is carried out, the burnt areas are under grass, with only a little Rubus (photograph 55). The essential difference seems to be that the Evelyn Valley area is protected from grazing. The other area is Native commonage, and grazing, which is at all times heavy and uncontrolled, becomes specially severe where burnt areas provide an early greenness. The Rubus here is not only stimulated, but is provided as well with a clear field to invade, free from grass competition.

PROTEA SPP.

Protea lacticolor dominates a mixed community common in the wetter parts of the ministerial grazing. With the exception of the plateaus, it covers a great deal of the country at the source of the Wolf River. Smaller patches line the upper reaches of the mountain streams and cover the flushes throughout the ministerial grazing. Although the Protea is often widely scattered, it seems by its presence alone, and not by its frequency, to be a reliable indicator of a moist vegetation. Other characteristic plants are:—

Agapanthus sp.	*Hebenstreitia dentata*
Anthospermum aethiopicum	*Hydrocotyle asiatica*
Anthospermum lanceolatum	*Hypochoeris radicata*
Athanasia punctata	*Kniphofia* spp.
Berkheya decurrens	*Leonotis* sp.
Cliffortia serpyllifolia	*Plectranthus calycinus*
Cluytia spp.	*Psoralea pinnata*
Cuscuta sp.	*Restionaceae*
Cyperaceae	*Rubus* spp.
Diascia rigescens	*Stoebe cinerea*
Euphorbia epicyparissias	*Trifolium* sp.
Gunnera perpensa	*Zantedeschia aethiopica.*

The Cuscuta may in many parts smother the plants under a heavy curtain of runners in vivid yellow patches several yards across. Away from this community it is rare. *Euphorbia epicyparissias* is usually scattered, but may dominate small areas of a morgen or so. The many other species occurring together with the plants listed are sometimes rare and sometimes common according to the locality, and it is doubtful if this patchiness is anything else than fortuitous.

The mixture may be open, as at Chatha, but often forms an interlaced mass, thorny with Rubus and up to 6 feet high, of which examples may be seen along parts of the Wolf River. It is then for practical purposes impenetrable, and gives outstanding protection where protection is most needed. Its value as fodder varies according to the vegetation of the community itself as to density and species.

Fire destroys the Protea plants but many of the seeds escape. There is evidence of this on the upper slopes of Geju Mountain, where among dead and blackened stems of the older plants a crop of 12-inch seedlings is coming up. After the fire of September 1948 (page 84), the seed escaped from the charred capitula and massed into drifts beneath the trees, sometimes a foot deep in hollows on the ground. It appeared unharmed, but no germination tests were carried out.

The flowers, ranging in colour from white to red, are out in midsummer. Although not as showy as most other members of the genus, the tree is nevertheless an ornamental one. It is otherwise unimportant.

Protea multibracteata is found scattered through the open sourveld and in drier localities than those favoured by *Protea lacticolor*. A note on Dyer's specimen No. 370 in the herbarium of the Albany Museum states that it is a tree 10 to 15 feet high. The specimen is from the Katberg. This Protea forms an open parkland on the high level country above the Dontsa Pass on the road between Keiskammahoek and Stutterheim. What appears to be a different variety grows on the Chatha East ministerial grazing. It has, just below the surface of the soil, a thick and gnarled part which sends up a few slender 3-foot flowering stems, and the species has been recorded by Henkel also as a "grass-land shrub". The two forms may be found together in this locality. The thick underground parts of the shrub make it unlikely that it is merely an immature form of the tree. Whether the differences in habit are inherent, or whether they are caused by the presence or absence of grass fires is not known.

The flowers resemble in size and colour those of *Protea lacticolor*, and are out at the same time. Mr. P. L. P. Clerk, who is a beekeeper at Kubusi Forest Station, states that they are a valuable source of nectar.

METALASIA MURICATA

This plant occurs also in the *Cliffortia linearifolia* community, but only near its upper limits. At these altitudes it grows into a tree up to 12 feet or more in height, with white inflorescences, and these tall specimens are found along the south-eastern border of the district, reaching their greatest size in the Evelyn Valley macchia. Elsewhere it is a rare species. There are a few here and there on the steep slopes below the cliffs of Geju Mountain, but these plants are dwarf shrubby forms not more than a foot in height. The inflorescences are pink instead of white. This colour variation is mentioned in the *Flora Capensis*, but without any remarks as to the habitat of the coloured specimens. It is possible that the colour is correlated with high altitudes, as has been recorded for various other flowers by Bews (1917b, p. 520).

The bushes are not readily eaten by stock and are too uncommon to be of importance. Like the Cliffortia and Erica they accompany, they are killed by fire.

BOBARTIA GRACILIS

There are about a hundred morgen under this community at Keiskammahoek. It is generally absent where the highland macchia occurs, and grows best in company with the *Cliffortia linearifolia* community. The scattered patches are usually dense, and end abruptly in a regular outline, intervening strips of country being often quite free of Bobartia. It occurs mainly on the plateau west of West Peak Pirie and in this neighbourhood, with smaller patches on Mount Kemp and on the terraces between Mount Kemp and Gwili-gwili.

Unless driven by starvation, no stock will attempt to eat it, for leaves and flowering stems are alike hard and wiry. It is exceptionally hardy, suffering no more than transient damage from burning, and thriving where there is heavy and uncontrolled stocking. The leaves and stems of each plant arise in a dense tuft and are too closely set to offer refuge to other less hardy species except on a very small scale. It may be used for thatching but does not appear to be put to this use locally, for suitable grasses are more plentiful and easier to obtain. In other parts of the country, durable basket-work and matting are made from it. At Keiskammahoek, therefore, although it has potential uses, it is at present nothing better than a nuisance.

PTERIDIUM AQUILINUM

This is the commonest fern of the macchia and forest margins. It has a thick subterranean rhizome which according to Sim (1915, p. 264) may be several yards long. The rhizome remains unharmed by fire and the new fronds are among the earliest signs of green after a macchia burn. In company with *Rubus* spp. it often dominates miles of forest firebreaks, for the regular manual clearing which is done on them is too superficial to damage the rhizomes. It has no economic value in the district. Theoretically it is poisonous to stock, for practical purposes it constitutes no danger to them (Collins and Wild, 1950, p. 17).

STOEBE SPP.

Stoebe cinerea and *Stoebe plumosa* are the two species which have been collected locally. *Stoebe cinerea*, the commoner of the two, is distributed patchily over most of the highlands, with concentrations in the vicinity of Mount Kemp and in parts of the Hogsback near King's Nek, and according to a note on Rattray's specimen No. 100 it covered large areas on the ridge between Amatole Basin and the Tyhume River in 1918. In the Bedford district it is becoming a serious pest on some of the farms in the Kaga Mountains. According to the *Flora Capensis*, it occurs "in dry ground and by roadsides, throughout the Colony", but locally at any rate it demands a good supply of soil moisture, communities of it being interrupted on dry slopes or where the soil is scanty by patches of Clffortia and Erica. Levyns (1937, p. 5) reports that it is "a plant of low and moderate altitudes" in the western Cape, but it grows well in the Amatole Mountains in places over 5000 feet above sea level.

By scrambling over the tops of other small shrubs it often smothers them so effectively that areas of a morgen and over may be entirely covered by it, in a closely-matted, yielding stand up to 5 feet high. Although it is useless to man or beast, it is nevertheless of value in binding the soil and protecting it from trampling by stock. It is very seldom eaten, and then only when young.

The closely-allied species *Stoebe vulgaris* has been studied in detail by Cohen (1935, 1940), and his findings would possibly give an indication of the behaviour of *Stoebe cinerea* also. They may be summarized as follows:—

1. There is no vegetative propagation.
2. Seeding and germination are good.
3. It is resistant to fire, but there are indications that frequently-repeated burning might kill it.
4. Seeds ripen in winter and are destroyed by fire.
5. It can establish itself best on open ground.
6. It is encouraged by heavy stocking, counts showing that there is twice as much Stoebe on grazed areas as on ungrazed areas.

Stoebe plumosa grows more sparsely, and is a smaller bush than *Stoebe*

cinerea. It has not been noticed in any extensive communities and is not at the moment a problem of any importance.

PASSERINA SPP.

The species recorded from Keiskammahoek are *Passerina montana*, *Passerina vulgaris*, *Passerina filiformis* and a species not yet named with certainty.

The unnamed species has been collected from the watershed between the Wolf and the Mnyameni Rivers and from the Katberg (Story Nos. 3778 and 3876, in the National Herbarium, Pretoria), but as a rarity only. It is at present of no economic importance.

Passerina montana is known from the eastern Cape to Southern Rhodesia, and from 3000 to 10,000 feet above sea level (Thoday, 1924, p. 153). On the northern of the two hills Mary and Martha, which are about 12 miles south-east of Tarkastad, it is dominant over most of the plateau, with relatively insignificant amounts of *Aster filifolius* and *Helichrysum trilineatum*, and a few dwarfed specimens of *Royena hirsuta* and *Euclea undulata*. As the hill in question is never grazed and is almost inaccessible even to people, one may conclude that something similar to this vegetation is likely to be the climax on the mountain tops in the neighbourhood. Yet on the southern of these two hills Passerina is almost absent, and grass is dominant over the whole plateau, in spite of the fact that conditions there are almost identical with those on the northern hill. It is nearly as difficult to climb, and only once have sheep been known to reach the top (Pio, 1948). Numbers of charred sticks, however, show that shrubs were once present in larger quantities, and the fact that the plateau was burnt in February 1946 provides an explanation for their present scarcity, and suggests that *Passerina montana* is in these parts the equivalent in function and behaviour of the Cliffortia and Erica of the Amatole Mountains.

Away from the mountain tops *Passerina montana* is absent probably because the Tarka climate is too dry for it except at high altitudes. The average rainfall for the district according to the rainfall map (Department of Irrigation, 1939) is less than 20 inches. Near the Winterberg, where the rainfall is between 20 and 35 inches, its range is not so limited, and it has within living memory encroached widely on parts that were formerly free of it (Liebenberg ms.). The reasons may possibly be the same as those put forward on page 82 for the recent increase in the Amatole macchia—less competition from the grasses and fewer fires.

As a means of control, Liebenberg suggests burning, or using goats to browse it, and gives an instance where goats have been used to good effect.

It was collected on the Hogsback by Rattray in 1920, but as it is 30 years later still not a common plant, the indications are that it cannot here compete with the more robust Cliffortia and Erica. If ever it does show signs of increasing at their expense, the possible cause may be looked for in a climatic change towards drier conditions.

Passerina filiformis dominates the western half of the small plateau which lies immediately north of the Mount McDonald beacon. The bushes are about 2 feet high, and in habit so much like *Cliffortia linearifolia* that at a distance they could easily be mistaken for it, except that their colour is a darker green. They show no signs of being browsed by stock, although the plateau is heavily grazed by cattle, and by donkeys in smaller numbers. The community is densest on the edge of the plateau overlooking the Amatole Basin, thins out towards the centre of the plateau and is absent on its eastern side.

No other communities of this bush have been found in the district, and why it should be confined to this particular area is unknown, but it appears robust and is reproducing itself well, and there is no apparent reason why it should not spread. As it would be most undesirable if this should happen (for it seems to be a useless species), eradication by hand is advisable as soon as possible, while the task is still an easy one. Killick (1950) who reports on its dominance on parts of Table Mountain, near Pietermaritzburg, states that it is destroyed by fire, but in the local patch the vegetation is kept too closely grazed to admit of burning, nor is the Passerina yet dense enough to burn without additional fuel.

Passerina vulgaris is widespread throughout the Cape Province and common in the Albany and Bathurst districts, where it dominates small areas along the coast and on stony hills inland. At Keiskammahoek it may grow anywhere in the macchia, but is nowhere common, and as a community it has so far been found only in a strip along the southern edge of the plateau on the southern border of the district, near the beacons Zanyokwe 97 and Zanyokwe Auxiliary 308 (see photograph 56). The strip is at present not more than 50 yards wide. The unpalatability of the bush is apparent from the way in which it remains undamaged among the few closely-cropped specimens of *Cliffortia linearifolia* and *Cliffortia paucistaminea*. The grasslands in the immediate vicinity are a transition between the sourveld and the sweetveld and indicate a rainfall of about 25 inches a year (see page 103). The conditions obtaining here appear to be the driest under which Passerina can exist, for away from the edge of the plateau the sourveld species are no longer found, and Passerina shows no sign of advancing into the sweetveld.

It is doubtful if this species can be distinguished without the inflorescence from *Passerina montana*, but the two may be told apart when in bud by the shape of the bracts.

VLEI VEGETATION

The vlei vegetation could with justification have been included under the grasslands, for it will be shown that where the vleis are protected the grasses make up an appreciable part of the cover. However, the presence of a pure macchia community in the forest vleis, and the absence of a pure grass community in any, throws the balance rather towards their being treated together with the macchia, and this arrangement has been adopted accordingly.

Odd bushes of *Cliffortia serpyllifolia* may be seen in both the lowland and the highland macchia, and commonly in seepage areas. The species is sometimes co-dominant on the plateau west of West Peak Pirie with *Pteridium aquilinum* round springs and along the banks of small streams, but the largest communities so far found are in three small swampy glades in the Wolf Ridge Forests, each a little less than an acre in extent. Here the Cliffortia is 6 to 7 feet high and its density may be judged from photograph 57. It is dominant to the exclusion of all other woody plants except *Rubus* spp., a very little *Erica brownleeae* and some dead or dying forest trees. One or two hummocks are high enough to have a dry soil, and they bear the normal vegetation of the surrounding forests; in the Cliffortia community the ground is oozy, with a black, peaty appearance. Various sedges are common everywhere among a rich ground flora in which the following genera are well represented: Blechnum, Cineraria, Geranium, Impatiens, Kniphofia, Mentha.

It is strange that this species of Cliffortia should be absent from a similar swampy area at Hunterstoun, on the plateau about a mile south-east of the Hogsback hotel. As it has been recorded from the top of the Amatole range at 6000 feet (Story No. 3668) it is certain that the climate at the Hogsback is not too severe for it. It cannot be a question of shelter, for the area is surrounded by an unbroken ring of pine plantations, nor can it be due to fire or grazing, for the ground has been protected from both for about 30 years. The constrastingly open appearance of this vlei by comparison with the forest vleis is shown in photograph 58, but it has nevertheless certain similarities in the presence on the hummocks of Rubus and a little *Erica brownleeae*, and in

the abundance of the sedges, which here completely dominate the ground flora. *Helichrysum fulgidum, Kniphofia* sp., *Leonotis leonurus, Nidorella auriculata, Zantedeschia aethiopica* and various forest ferns are scattered throughout, together with small communities and individuals of the grasses *Anthoxanthum ecklonii, Miscanthidium capense, Pennisetum macrourum* and *Pentaschistis* sp., the whole forming a dense cover and giving rise to a thick mat of decaying vegetation on the surface. *Cliffortia linearifolia* and *Pteridium aquilinum* also grow among the Rubus and Erica on the mounds.

The appearance of a vlei in the ministerial grazing is shown in photograph 59. Trampling and grazing between them have cleared away all the tall growth and all the litter. What remains is a closely grazed collection of small mounds, about a foot high and a foot across, separated by a network of drainage channels. The reason for this peculiar formation appears to be bound up with the grazing, for the protected areas do not show it, and it is probably caused by the way in which cattled tend to avoid the large and coarse tufts of vegetation at the expense of the smaller stuff between them, which provides easier going and better grazing. The resulting drainage is a very serious matter, the drying of the soil and denudation having in some cases gone far enough to permit the establishment of *Helichrysum argyrophyllum* on the mounds. This is now being arrested by the fencing of the vleis in the Native areas and the ministerial grazing, and the resulting changes in the cover are likely to be spectacular and to have far-reaching results. The vegetation at present consists almost entirely of sedges, the commonest being species of Scirpus and Tetraria. *Juncus lomatophyllus* is usually dominant near the lower end of the vleis where there is an abundance of soft mud and slowly-moving water. As at Hunterstoun, *Cliffortia serpyllifolia* is absent, and the other macchia shrubs practically so, nor is there any sign of macchia invasion.

SUMMARY:

INTERRELATIONS OF THE WOODLAND TYPES

TYPE 1

The relationship of type 1 (*Acacia karroo*) to the driest scrub, with a rainfall below 15 inches, has already been discussed. Acacia is found only in localised areas where conditions are specially favourable, and is clearly a post-climax community. There are no examples of this dry scrub in the district for the rainfall throughout is too heavy.

Where the rainfall is higher but where the habitat is in other ways unfavourable to the easy development of the mixed scrub of type 2, the Acacia persists as dense consocies, the succession slowing down in proportion to the unfavourable factors. It appears that the most important of these is exposure to wind, for the reasons discussed in chapter 4.

In type 2, which has a rainfall of 23 inches or thereabouts, there is ample soil water for the needs of Acacia, and it forms an integral part of the scrub.

It is not a constituent of types 3 to 5. Because of their deeper shade, it can grow only on their margins and in their glades, in the role of a pioneer (see page 65). The tendency is for these types to spread by extending their margins and by encroaching on the glades—*Acacia karroo* thus occupies an area which is constantly dwindling in size, and in the absence of disturbance it must in time disappear more or less completely. At Round Hill (page 104) it may be particularly clearly seen that Acacia is more xeric than these types. It occupies the northern slopes to the exclusion of other trees, but on the mesocline there is mixed bush approximating type 4. The two aspects are shown in photographs 4 and 5.

Types 6 and 7 are not associated with the Acacia in any way.

TYPES 2 TO 6

Types 2 to 6 in order occupy regions of increasing rainfall and are often in contact with one another, each with the lower limit of the one above it.

TYPE 7

Type 7 (the macchia) is associated with the forests (types 5 and 6), but is never found inside them.

Around type 5 it grows usually at the upper limits of the forest—at Lenye Forest Station for instance its first appearance is on the plateau where the plantations are, at an altitude of 3200 feet.

Forest patches falling under type 6 may have macchia at the top and bottom, and examples of this occur on the hills between Charybdis and Evelyn Valley.

It is noticeable that the forests occupy the steep slopes and the sheltered basins rather than the plateaus, flats and ridges, which are usually under macchia. This observation will be found to hold good in all the forest country, but there is a further point to be noted with respect to the highlands at about 4500 feet and over. This is that the forests become increasingly sensitive to exposure as the altitude increases. There is a definite timber-line, often coinciding with an escarpment, and above this one finds the forests absent except as shreds in deep gorges or in the shelter of piles of rock. The macchia, on the other hand, is by comparison little affected, and continues as a flourishing community to the summit of the Amatole range. The grasslands often accompany it, as is discussed in chapter 4. At the lower altitudes, the macchia acts as a pioneer to forest (page 79), above the timber-line it rarely does so.

CHAPTER 3

GRASSLANDS

GENERAL

It must be emphasised that tree growth may be found in places throughout the grasslands, and that there is no forest, however dense, which does not harbour a few grasses among its undergrowth. It is thus only for convenience' sake that the grasses and trees are at first considered separately. Their inter-relations are discussed in chapter 4.

An examination of the aerial photographs is alone enough to establish beyond question the importance of the grasses in the Keiskammahoek district. As they are found over areas in the lowlands and on the mountains, one would expect communities to differ in accordance with the large variations in their habitat, and an examination shows that in fact they do, and that they fall naturally into two great classes. The class in the warm areas with a low rainfall is known as the sweetveld, that in the cooler and wetter areas as the sourveld, and the dividing line between the two is between the 25-inch and the 30-inch isohyets. This is a general rule not only at Keiskammahoek but throughout the country generally, as may be confirmed by a comparison of the rainfall map (Department of Irrigation, 1939) and the vegetation map (Acocks, in press).

The names are unconnected with the usual conceptions of sweet and sour and for that reason are meaningless, but as they are so widely known and as there are no alternatives, they are being used in this paper. Many writers, among them Sim (1894), Pentz (1938), Irvine (1941), Scott (1949) and Acocks (ms.) have recognised these two types and have dealt with them from various points of view. There are different forms of sourveld and sweetveld, but they have a number of characteristics in common and the remarks which follow are applicable to all.

The essential feature distinguishing the two classes is that the sweetveld remains palatable during the winter and the sourveld does not. Throughout the year, cattle may be maintained in prime condition in the sweetveld without supplementary feeding, in the sourveld they fall off in condition as autumn approaches, and this no matter what bulk of the natural grass is available to them. Similar conditions have been described also for Natal by Pentz (1938, pp. 9, 13). There is as yet no satisfactory explanation for the short-lived palatability of the sourveld species. Sim (1894, p. 13) states that the reason is because "the very wide range of temperature between morning and midday during frosty weather is such that the herbage is suddenly rendered worthless and unpalatable, and gives much less nourishment than when it is dried off naturally by dry weather", but this view is untenable for the reason that the sourveld extends down towards the coast into localities where frost is practically unknown. Additionally, Figure 2 shows that the temperature range is greatest at Fort Cox and Lenye in the sweetveld zone and least at the macchia and Helichrysum stations in the sourveld zone.

The sourveld consists of tall bunched grasses vigorous in growth, in the sweetveld the grasses are often smaller and low-growing. Cynodon and Digitaria have the habit of spreading by means of runners more than by seed, and by their high frequency they are able to lend this character to the sweetveld as a whole. It is incorrect, however, to state that the development of stolons is common among the different sweetveld species. In the Border area at any rate there are only a few others of which this is true—*Tragus koeleroides*, *Danthonia curva* and *Chloris virgata* are the examples which come to mind. The first two are uncommon and *Chloris virgata* has the habit only weakly developed.

The sweetveld is almost always mixed with thorny scrub, the open grassland being so restricted that in the vegetation map of the Union (Acocks, in press) it is treated as part of the Valley Bushveld instead of being shown separately. The sourveld at Keiskammahoek is for practical purposes the same as the Highland Sourveld of Acocks's vegetation map, and as may be seen in the Transkei, there are often huge areas of it which are devoid of woody growth. Where trees and shrubs do grow in it, they are not thorny. The Keiskammahoek macchia and forest patches are examples.

It appears for the following reasons to be a simple water relation which determines whether the veld is sweet or sour.

1. The sourveld is always associated with a high rainfall, as has been pointed out, and its habitat, although often drier than is immediately apparent (page 123 and those following) is probably wetter than that of the sweetveld.

2. At the upper limits of the sweetveld it is often found that rocky outcrops and boulder-strewn hills support sourveld species. By picturing a piece of ground with rock outcropping over half its area, one may understand that practically all the rain falling on the rock will run off and wet the ground, and that the ground will in effect receive double the rainfall of the surrounding area. This theory is mentioned in *The Farmer's Weekly* of 2nd February 1949 (a quotation from Klintworth in *Farming in South Africa*), and is a likely explanation of the stony islands of sourveld which may be found in the sweetveld plains of the Orange Free State along the main road between Colesberg and Johannesburg. In size they are sometimes as little as a few square yards and may contain only one or two sourveld representatives. Similar islands occur on the Themeda plains of the Grahamstown commonage, where the following grasses have been observed: *Eragrostis capensis*, *Eulalia villosa*, *Festuca scabra*, *Harpechloa falx*, *Trachypogon capensis* and *Tristachya hispida*. These species are not found in the vicinity where the ground is level and free from rocks.

The remarks on the islands apply only if the soil is deep enough for grass to grow. If it is too thin, it dries out very rapidly after rain and xerophytes alone can maintain a footing in it. *Lithops leslei* is an example from the northern Orange Free State, and *Microchloa caffra* and *Aristida* spp.; near Grahamstown *Euphorbia valida* is common together with the grasses mentioned.

3. Sandy soil is the rule over wide areas of the Bathurst and Alexandria districts, extending from Martindale southward. An anomalous spot is Round Hill, near the siding of that name on the railway between Grahamstown and Bathurst. It is an island of loam in an area of sand, and the geological map (Department of Mines Geological Survey 1946) shows that two geological systems are involved. The vegetation is likewise different, for the loam supports sweetveld species only and the surrounding sandy flats support the sourveld species listed in paragraph 2. A similar relation on a larger scale is shown by the absence of the sourveld species in the Standerton, Bethal, Heilbron and Vrede districts, where the sward is an exceptionally pure standard of *Themeda triandra*. The rainfall is over 25 inches a year and hence is theoretically adequate for sourveld, or at least for a sprinkling of sourveld species, such as occurs respectively on the northern border of this area and on the eastern border of the Orange Free State, both with the same rainfall. The difference lies in the soils, which are a heavy black turf in the Themeda area, and which are lighter where the sourveld is.

The evidence is that where the rainfall is between the needs of sweetveld and sourveld, a light soil will throw the balance in favour of the sourveld, and conversely. An explanation is to be found in the higher water-retaining capacity of the heavy soils (Maximov, 1929, p. 63). This makes them a physiologically drier habitat in which the moisture-demanding sourveld species cannot thrive. In the physiologically wetter sandy areas, however, their water-requirements can be met, and they are able to compete successfully with the sweetveld species. Clements (1934, p. 49) reports that in America also "probably the most dramatic, as certainly heretofore the most puzzling, compensation for desiccation has been that afforded by sand hills and sand plains."

It is ignorance of this which has given rise in *The Farmer's Weekly* to much uninformed criticism of the article by D.W.G.S. (1949, pp. 46–51), in which he mentions the former layer of sandy soil over the surface of the karroo, and ascribes to its recent removal a great deal of the deterioration which has since taken place in the karroo vegetation. Whether the sandy soil was there or not is a matter which geologists could best decide. If it was, there is little doubt that it could have supported a more mesophytic type of vegetation.

SWEETVELD

COMPOSITION, AND EFFECTS OF GRAZING

In dealing with the bewildering number of forms which the sweetveld can assume, one is faced with two main variables which must be taken into account: rate of stocking and climate.

Most of the sweetveld has been overstocked for many years and has in the course of time changed out of recognition. The worst areas are bare and thus possess the one essential feature of a desert.

Areas less heavily stocked are thinly covered by shrubs and a growth of Cynodon, and their vegetation corresponds in form closely to that of the karroo. There is a relation in species composition too, but it is the inedible or at least unpalatable elements of the karroo flora which are most strongly represented, and it is difficult to attribute the disproportion to anything other than that the nutritious species are kept out by uncontrolled grazing. The commonest shrubs are *Chrysocoma tenuifolia* and *Aster muricatus*. *Chrysocoma tenuifolia* is poisonous and may cause heavy losses in parts which have been denuded (Steyn, 1934, pp. 393–406) such as these artificially induced karroid areas invariably are. A contributory cause of a karroo-like appearance to the veld is a weedy growth of *Selago corymbosa*. It is avoided alike by all kinds of stock, and from the manuscript reports of Dyer it is plain that this plant is another response to uncontrolled stocking. He found that "by resting camps and allowing grass to grow, nearly all the young plants are killed apparently due to the effect of shading." Although in the Albany district there are farms heavily infested with this shrublet, it is only of minor importance at Keiskammahoek.

Under improved conditions the grasses assume dominance. At first the cover is sparse and poor in grazing value, a ragged mixture of *Cynodon*, *Aristida* and *Eragrostis* spp. *Themeda triandra* is scarce and in certain places is all but unknown. Sometimes its disappearance is complete enough to suggest that it never was a native in certain places, for example along parts of the road between Fort Beaufort and Alice, but the vegetation along the neighbouring railway track reveals the true state of affairs.

The best sweetveld areas are marked by an almost pure stand of *Themeda triandra*. Karroo bushes are absent, and by comparison with the sourveld the non-grasses are in general uncommon.

An examination of the sweetveld according to the climate reveals an analogy between the effects of rainfall and rate of stocking, that is, low rainfall causes a diminution in the amount of Themeda with a corresponding increase in the proportion of *Digitaria, Sporobolus, Eragrostis, Aristida* and *Cynodon* spp., and with progressing dryness the change continues through karroo to desert.

These observations may be summed up thus: the better the conditions of grazing, or the higher the rainfall, the greater the proportion of Themeda in the sward.

Optimum conditions are represented in the cemetery at Keiskammahoek, which is grazed only occasionally and where the rainfall averages about 24 inches a year. The grass cover is shown in photograph 60, and quadrat figures are given in Table 34.

In protected areas *Panicum maximum* grows only where the ground or the vegetation has been recently disturbed, and it does not mix with the Themeda. Along the railway line, for instance, it grows on the embankments, and in the Keiskammahoek cemetery it grows along the edges of the paths and on the graves. This shows that it is low in the succession, and it is therefore at first somewhat surprising that it should be a rarity in parts where grazing is uncontrolled. It is found where it is protected by scrubby tree growth, but Mr. E. D. Matthews (page 56) has pointed out that it is well capable of growing in the open, as is shown on old fallow lands on his farm. He is of the opinion that its general absence in clear spaces is simply because it is prevented by the stock from growing there. Its palatability and its upright habit are certainly a fatal combination and support his view.

OTHER COMMUNITIES

ORNITHOGALUM THYRSOIDES

Some of the variations from the usual changes induced by uncontrolled grazing warrant special mention. A spectacular and well-known example is from the immediate vicinity of Keiskammahoek—*Ornithogalum thyrsoides.* When the plants come into bloom in the early summer they are a very striking sight, and an idea of the appearance of the veld may be gained from photograph 61. Their thriving condition and their abundance make it difficult for the layman to believe that they are a recent invasion related to overstocking, but there are several strong arguments in favour of this. They may be briefly stated as follows:—

1. Photographs taken by Mr. E. D. Beale to show the Ornithogalum and dated Christmas 1923 are not of the area where it is now most common, but were taken some distance out of town, one on the road to Chatha Forest Station and the other on the road to St. Matthews. Copies of the photographs are in the files of the Botanical Survey Section, Grahamstown. Although it cannot logically be inferred from this that there was no Ornithogalum nearer the town, there is a probability that this was so.

2. Dr. R. A. Dyer has mentioned that in about 1926, when he was working on the Helichrysum experiment described by Schonland (1927), Ornithogalum grew on the slopes of Bumbane Hill, but there was none round the town itself.

3. On 3rd November 1948, belt transects of 4 x 108 yards were done in the cemetery (rarely grazed), in the camp on its south border (closely grazed) and in the unfenced part north of the cemetery, which is an uncontrolled thoroughfare for stock (severely overgrazed and trampled). The Ornithogalum plants totalled 77, 994 and 4760 in order from the lightly grazed to the most heavily grazed area. This gives an average number of

TABLE 34

POTENTIAL COMPOSITION OF SWEETVELD

A. Woodland Type 1 (Keiskammahoek Cemetery). Square metre quadrats

Species	Quad 1	Quad 2	Quad 3	Quad 4	Quad 5	Quad 6	Quad 7	Quad 8	Quad 9	Total
Anthericum sp.					0·02					0·02
Chaetacanthus setiger ..					0·01					0·01
Crabbea nana			0·01	0·01						0·02
Digitaria eriantha				0·01		0·04	2·43		0·11	2·59
Eragrostis capensis ..	0·01				0·31			0·11		0·43
Eustachys paspaloides ..				0·35		0·09				0·44
Helichrysum nudifolium ..				0·17	0·03	0·01				0·21
Hermannia sp.						0·01				0·01
Indigofera sp.			0·11		0·07			0·01	0·02	0·21
Oldenlandia amatymbica ..						0·01				0·01
Pelargonium reniforme ..		0·01		0·01			0·01			0·03
Rhyncosia sp.		0·02		0·06	0·01		0·20	0·01	0·01	0·31
Senecio retrorsus		0·02								0·02
Sporobolus fimbriatus ..								0·02	0·04	0·06
Tephrosia sp.			0·09		0·01			0·03		0·13
Themeda triandra	13·48	7·95	6·03	7·60	8·81	5·75	5·93	8·53	9·28	73·36
Thunbergia sp.							0·01			0·01
Tragus koelerioides ..							0·01			0·01
Vernonia sp.		0·10		0·04	0·07					0·21
Indeterminable					0·01		0·01	0·01	0·27	0·30
	13·49	8·10	6·24	8·24	9·36	5·91	8·60	8·72	9·73	76·39

Average Basal Cover 76·39/9 = 8·49 per cent.

Table 35

POTENTIAL COMPOSITION OF SWEETVELD

B. Woodland Type 2 (Protected ground at Fort Cox). Square metre quadrats

Species	Quad 1	Quad 2	Quad 3	Quad 4	Quad 5	Quad 6	Quad 7	Quad 8	Total
Abutilon sonneratianum					0·05				0·05
Aizoon glinoides								0·43	0·43
Aristida bipartita		0·45		0·72		0·09	0·58		1·84
Brachiaria serrata		0·16	0·02	0·93	0·64		0·02	0·18	1·95
Digitaria eriantha	2·18	0·01	4·17	8·75	0·02	8·18	9·06	0·48	32·85
Helichrysum sp.					3·97	0·01			3·98
Hypoxis sp.						0·01			0·01
Panicum maximum					3·18				3·18
Phyllanthus maderaspatensis			0·01					0·02	0·03
Sedge					0·08				0·08
Senecio burchellii							0·01		0·01
Setaria perennis							1·85	15·39	17·24
Sutera atropurpurea				0·03		0·03			0·06
Themeda triandra	18·80	14·10	11·66	0·36		8·82			53·74
Indeterminable						0·01		0·01	0·02
	20·98	14·72	15·86	10·79	7·94	17·75	11·52	16·51	115·47

Basal Cover 115·47/8 = 14·43 per cent.

plants to the square yard of 0·17, 2·30 and 11·0. The dense infestation of the surroundings contrasts strangely with the cemetery. While it is evident that infestation is encouraged by heavy stocking, there is a limit to this process, and beyond this limit the correlation breaks down. A transect along a wide cattle-path showed in figures what was plain to the eye, and what is merely axiomatic, namely that an extreme amount of disturbance will inhibit the growth of these plants. The path in question is about 16 yards wide, covered in Cynodon and slightly sunken. There were 208 plants in the transect, or 0·48 to the square yard. It is the mechanical effect of the trampling alone which prevents the plants from becoming established, and not exposure to the sun. This is indicated by the way the young seedlings come up in hundreds in completely denuded areas—in fact, strong light appears vital to them because they are never found in dense mixed scrub or under shady Acacia trees.

Ornithogalum thyrsoides is a stock poison (Steyn, 1934, p. 517) but is a potential danger only in the summer for the reason that the above-ground parts (leaves and flowering culms) die back when flowering is over. Steyn's information that it causes losses mainly when mixed with hay and that it is very rarely eaten under natural conditions is confirmed by the fact that no losses were reported from Keiskammahoek although the stock had free access to the heavily-infested areas when the plants were in the full vigour of their growth.

The species has the means of spreading rapidly if there is a favourable combination of the circumstances mentioned. Flowering may be delayed or suppressed by drought, but in a good year begins in early October and the young plants as well as the mature ones take part. The culms are usually from 12 to 15 inches in height, but even the two-inch culms of plants a few seasons old can produce reduced spikes of normal flowers. They continue in full bloom for six weeks and over, then the flowers rather suddenly come to an end, the leaves wither away and the culms alone are left standing, bleached and papery. Counts showed that the average plant produced about 28 flowers and that each flower produced an average of nearly 46 seeds. A square yard of a badly infested area might at this rate be expected with one crop of flowers to drop over 14,000 seeds. They are wind-distributed. The persistent capsules dehisce at the top, and with the shuddering movements which the wind produces in the rigid culms the seeds are sprinkled around as from a minute pepper-pot. They are a deep but dull black, the size of a pinhead and sharply angled. They are mature a few weeks after they are shed, probably even earlier than this, and may be stored for a year at least without any lessening of their viability. The first signs of life may appear on the third day after the germination test is begun, thereafter germination may continue very irregularly for ten weeks and more to a total averaging 92 per cent.

Ornithogalum thyrsoides has not been seen in the sourveld.

BULBINE ASPHODELOIDES

The land round the town which is now occupied by Ornithogalum was until 1928 at least under a thick growth of *Bulbine aphodeloides*. I have seen five different photographs taken with a view to illustrating this fact, and they suggest that the show of flowers was something out of the ordinary and a sight worth recording. One of the photographs is reproduced (photograph 62). On the original photograph, a note by Dr. R. A. Dyer states that *Bulbine asphodeloides* had been spreading rapidly in the last few years on the town commonage and Native settlements, and was becoming a "serious menace to the grazing capacity of the veld." Although it is still to be found in this vicinity, the plants are now so thinly scattered as to be scarcely noticeable, and the reasons for its former complete dominance and its subsequent disappearance are at present inexplicable. In other parts of the district it is still present in patches several morgen in extent, of which the best examples are at Gwili-gwili and Gxulu. It has conspicuous heads of yellow flowers which were in bloom in 1949 from January to March.

THE TRANSITION ZONE

As with the woodland types, the transition in the grasslands from one type to the other is gradual. From the surroundings, the ecotone between the sweetveld and the sourveld may be recognized by the composition of the neighbouring woodlands (which are typically between types 3 and 4) and the scarcity of Acacia and the large, clean-stemmed habit of such Acacia as does exist. The pasture resembles the sweetveld proper in its domination by *Themeda triandra*, but scattered individuals of the sourveld species begin to make an appearance. It is mentioned in the account of type 4 that the first ones are likely to be *Harpechloa falx* and *Tristachya hispida*. Others slightly less common are *Eulalia villosa*, *Koeleria cristata* and *Alloteropsis semialata*. Usually the closely-cropped condition of the sward makes them difficult to recognize, but *Hyparrhenia buchananii* is another safe indicator of the transition and its coarse flowering culms often escape being grazed so that the plant may be recognized more easily. It is very rare in the sweetveld where it can sometimes live precariously if it is protected from the setbacks caused by grazing and trampling. One or two plants grow in the Keiskammahoek cemetery, but no others have been seen in the vicinity, the rainfall of which averages about 24 inches a year. Even in the transition zone, it does not occur extensively, and favours the banks of streams and dongas more than the open veld. It thins out rapidly as it nears the sourveld itself, and finally disappears near its borders.

The scraps of Hyparrhenia represent in a very attenuated form the Tall Grass Veld described by Pentz (1938) and Acocks (in press). Where the Tall Grass Veld attains its best development is in Natal, and there it forms a broad and irregular belt between the sweetveld—shown as Eastern Valley Euphorbia Scrub by Acocks—and the sourveld. It appears again in smaller quantities forming a buffer between these two veld types in the Transkei, but diminishing towards the south until in the Ciskei it is no longer of sufficient extent to be shown separately.

Elyonurus argenteus is not found until the upper limits of the sweetveld are reached, and its first appearance is therefore another indication of the transition zone. Unlike Hyparrhenia, however, it is a component of the sourveld throughout. Though widespread and common in the Union as a whole wherever the rainfall is over about 25 inches, it is in the lower parts of the Keiskammahoek district curiously patchy in its distribution. Except when it is forming new growth, animals avoid it whenever possible on account of its strong taste. It therefore does well where grazing is uncontrolled and heavy, being stimulated by a certain amount of incidental disturbance from the stock but receiving no serious check from grazing and finally giving rise to a tussock veld like the example shown in photograph 63. The trampling mentioned, as long as it is not excessive, contributes to the healthy growth of Elyonurus, for if protected from disturbance it has a propensity for dying out after accumulating a mass of leaf which appears to smother the parent plant The dead tufts rot through at ground level and come away very easily with wind or rain or trampling.

Conditions round the town are probably too dry for Elyonurus and so far none has been found there except near the western limits of the golf course where some low-lying ground collects the run-off from a ridge to the south, and is in addition occasionally flooded when the river is in spate. The slightly increased dampness of the ground is apparent from a scattered growth of *Andropogon appendiculatus*, *Artemisia afra* and *Rubus* spp., and Elyonurus is one of the grasses in this community.

SOURVELD

COMPOSITION, AND EFFECTS OF GRAZING

The sourveld consists in its most typical form of a mixture of grasses similar to those occurring from Stutterheim through the Transkei to the Natal highlands, described by Acocks (ms.) as Highland Sourveld, and shown in photograph 64. In the Keiskammahoek district it is now found only on about 200 morgen on the mountains north of the house at Chatha Forest Station, and on the upper slopes of Mount Thomas, so that its area is negligible, but historically and potentially it is a very important veld type.

The upper limits of the sweetveld and the lower limits of the sourveld are often dominated by Themeda, commonly mixed with the following in varying proportions:—

Brachiaria serrata	*Heteropogon contortus*
Elyonurus argenteus	*Setaria flabellata*
Eragrostis capensis	*Sporobolus capensis.*
Eragrostis chalcantha	

In respect of these species the two types are similar, but besides by the tests mentioned on pages 103–4 the sourveld may may be distinguished by the presence of one or more of the following grasses:—

Harpechloa falx	*Sporobolus centrifugus*
Tristachya hispida	*Aristida galpinii*
Alloteropsis semialata	*Aristida junciformis*
Andropogon appendiculatus	*Eulalia villosa*
Trachypogon capensis	*Panicum ecklonii*
Koeleria cristata	*Panicum perlaxum*
Eragrostis caesia	*Digitaria diagonalis.*

They are arranged roughly in order of frequency, those down to *Sporobolus centrifugus* being fairly well distributed, and those below being patchy or rare. None of them are found in the sweetveld. There is a wealth of corresponding non-grasses, but they vary so widely from place to place that it is felt inadvisable at this stage to arrange them in order of frequency, without excepting even the commoner ones that follow:—

Alchemilla spp.	*Erica floribunda*
Argyrolobium speciosum	*Haplocarpha scaposa*
Aristea schizolaena	*Helichrysum* spp.
Aspalathus spp.	*Hypoxis argentea*
Aster bakerianus	*Indigofera hedyantha*
Caesia eckloniana	*Leyssera gnaphaloides*
Centella glabrata	*Lightfootia huttoni*
Cliffortia linearifolia	*Lobelia erinus*
Cliffortia paucistaminea	*Phylica galpinii*
Cotula hispida	*Relhania trinervis*
Cycnium racemosum	*Stoebe cinerea*
Dobrowskya scabra	*Stoebe plumosa*
Erica brownleeae	*Zaluzianskya capensis.*

This Themeda-dominant sward referred to is low in the sourveld succession, consequently it is not a stable community except in the position stated—at the lower limits of the sourveld. Its dominance elsewhere in the sourveld than here is a sign of a change brought about by grazing animals. That is why Themeda is so common in areas reclaimed from Helichrysum. Schonland time and again emphasizes its abundance in the plot in the Gxulu commonage, and the same thing is evident at King's Nek today. Further protection brings about a gradual preponderance of the grasses peculiar to the sourveld. Whether this is desirable from the point of view of soil conservation and grazing could probably be established from results obtained at the Dohne Experiment Station.

The soil grows darker with increasing altitude and takes on a peaty texture. It is generally moist, with oozy places below the cliffs and round the edges of exposed sheets of rock. Particularly on the shady slopes, there is a gradual admixture of new grasses which by their abundant and rank growth hide the dips and hummocks and stones from view and give the veld a peculiar softened appearance. This appearance is misleading, for the grasses causing it usually have leaves harsh and pungent, and the grasses which are in reality soft are smaller and hidden from view. The following grass species are characteristic of the parts near the top of the Amatole range, but their relative frequencies are not sufficiently known to be stated:—

Agrostis barbuligera	*Bromus speciosus*
Agrostis bergiana	*Festuca caprina* var. *irrasa*
Anthoxanthum Ecklonii	*Festuca costata*
Aristida galpinii	*Festuca* sp. nr. *Festuca caprina*
Aristida junciformis	*Pentaschistis* sp. nr. *Pentaschistis juncifolia*
Brachypodium flexum	
Bromus firmior	*Poa binata.*

The associated non-grasses in number and variety far exceed those of the lower altitudes, and the following list gives no more than a very general idea of those commonly found:—

Anthospermum aethiopicum	*Helichrysum* spp.
Anthospermum lanceolatum	*Hypochoeris radicata*
Athrixia phylicoides	*Lepidostephium denticulatum*
Berkheya decurrens	*Nemesia melissaefolia*
Cineraria deltoidea	*Ornithogalum subulatum*
Cineraria lyrata	*Peucedanum capense*
Cliffortia eriocephalina	*Restionaceae*
Cliffortia paucistaminea	*Rubus* spp.
Cluytia katherinae	*Rumex sagittatus*
Diascia rigescens	*Scabiosa tysonii*
Dierama sp.	*Selago galpinii*
Erica alopecurus	*Senecio paucifolius*
Eucomis sp.	*Tritonia lineata*
Geranium ornithopodum	*Wahlenbergia rivularis.*

This mixture continues to the summit wherever there is a fair depth of soil, as there is on the ridge running from Mount Thomas towards the west. Along most of the escarpment's edge, however, there are outcrops of rock and consequently a thin and scanty soil, and in these parts there is a marked difference in the vegetation. All the grass species are present, but it is the Aristida species that predominate, and an irregular growth of *Arundinaria tesselata* occurs in the district nowhere else but among the piles of rock in this area. A scanty growth of dwarfed shrubs is remarkable for its similarity in the matter of hard mucronate leaves and a dense woolliness, and rosette plants, *Restionaceae* and succulents are well represented. The surroundings as a whole convey a sense of bleakness and desolation, and this is often heightened by the wind, for the peaks are in the path of every wind that blows.

The following are some of the plants characteristic of the area:—

Arrowsmithia styphelioides	*Mesembryanthemum* spp. (in the broad sense)
Aspalathus spp.	
Chrysocoma tenuifolia	*Muraltia macroceras*
Erica spp.	*Phylica galpinii*
Euryops dyeri	*Passerina montana*
Helichrysum spp.	*Ursinia apiculata.*

On the north side this vegetation ceases where the rock dips below the soil, giving way to the gentle treeless slopes of sourveld in which the streams drain away into the Kei River. Peaty soil and the accompanying abundance of herbs and rank grasses are not a feature of the northern side, and in all essentials this sourveld is the homologue of that on the south side a thousand feet lower down, as is discussed further in Chapter 4. The sourveld passes gradually into the sweetveld at an altitude of about 4500 feet, Happy Valley post office being on the border between the two. Most of the veld in these surroundings no longer shows any trace of sourveld species. Themeda is the dominant grass, associated with a great number of karroid non-grasses like *Lycium oxycladum*, *Eriocephalus* sp., *Cotyledon orbiculata* and *Aster muricatus*. It is only in protected places where a few specimens of *Harpechloa falx* remain to indicate the veld's true affinities.

The peaty soils at high altitudes on the south side are soft and easily damaged by trampling. They wear into deep paths, and where the underlying rocks are close to the surface whole sods may come away, leaving a face of ground without support to form a starting-place for extensive erosion. The harm is aggravated by the invariable steepness of these parts. From Geju Mountain on 4th November 1948, sixteen landslides could be counted in the upper Mnyameni basin, varying in length from a few yards to many hundreds. The basin is wrinkled with paths, which give evidence of heavy stocking, and the outlines of new and old burns show that the vegetation is burnt irregularly and often.

OTHER COMMUNITIES

HELICHRYSUM ARGYROPHYLLUM

General

Below the region of friable soil it takes hard trampling in the sourveld to produce a bare area. Where trampling is not so heavy, and particularly on the xerocline, the grasses as they become weak and sparse are covered by a mat of *Helichrysum argyrophyllum*, which protects them from further injury. Clements (1935, p. 365) is of the opinion that "grassland binds the soil with roots as no other community does". In the Helichrysum areas most of the grass roots still remain, and there are the thick Helichrysum cushions over them to form a practically unbroken covering to the soil. As a protection, this combination is an effective one, and erosion in the Helichrysum areas as a whole is not spectacular. Gullies can form only where the community has been destroyed. There is a little tunnel erosion in different parts. The district is fortunate in having conditions suitable for this Helichrysum, which Schonland (1927, p. 6) has described as "a blessing in disguise". The most important observations presented in his paper are as follows:—

1. About 60 square miles were covered by this plant in 1923, in Keiskammahoek and the adjoining areas.
2. It owes its dominance to the destruction of the original grasslands.
3. It is a pioneer species and gives way to grass if the area is protected.
4. Grass can continue to exist beneath the mats it forms.
5. Burning destroys it, and grass will re-establish itself in 18 months if the area is burnt and then rested.
6. It forms a thick layer of humus which guards against erosion by holding soil and water.

There has been a further paper on *Helichrysum argyrophyllum* by White (1948), who confirms Schonland's observations. He estimates that there are now about 100 square miles infested by the weed, and by this clearly illustrates the steady deterioration of the Amatole pastures.

I have a few additions to make to these data, but no criticisms to offer.

Present Trends

According to a leader in the *Daily Dispatch* of 23rd August 1927, Helichrysum was causing anxiety about 1907, but occupied a relatively small area. White's observations on its spread are confirmed by photographs 65–6, taken respectively about the time Schonland's work began (1923 or thereabouts) and in 1949. At the present time, grasses growing through the Helichrysum are still able to supply meagre grazing to stock, but these relicts are becoming scarcer. In consequence the cattle are forced to go in search of food into the most remote and inaccessible parts of the district, where the same story is being repeated that had its beginning in the more populous parts of the highlands 50 years ago. Photograph 67 shows the cattle grazing a slope which has so far remained more or less untouched because of its steepness. Here and in this vicinity the grasslands are now gradually breaking down, those on the xerocline being the first to go, those on the mesocline lasting longer because of the better conditions which give them a stronger hold on life, and tending towards macchia rather than Helichrysum. The end either way is total destruction of the grass cover, and its progress may be seen in photographs 37–8. If these areas are taken in hand, it follows naturally that the time taken for a sward to become re-established will be longer on the xerocline.

Propagation and Enemies

The plants come into full flower near the middle of April, but for some unknown reason this takes place sooner on level ground and is delayed on slopes, irrespective of their aspect or area. On 8th April 1949 the Helichrysum was only just beginning to come into bloom, yet tiny seedlings were found that appeared to be not more than a week old. These could have arisen only from the seed of previous seasons, and show that the seed may lie for a year at least without germinating.

Its only biological enemy that has been noted is a species of grasshopper, associated with the Helichrysum and probably dependent on it for food, which may be inferred from the fact that it has so far not been seen on other plants. In size it is a little under half an inch and in colour a perfect match with the silvery sheen of the Helichrysum leaves. There are, however, not enough of these insects to constitute the slightest threat to the host plant, which yields its place only in the normal course of plant succession, or in the face of trampling or fire. Domestic animals will not touch it. Mr. F. J. Stayner, at one time District Forest Officer at Keiskammahoek, tethered a goat in dense Helichrysum near Schonland's plot in the early 1920's, supplying it with drinking water but no fodder. It refused consistently to eat the Helichrysum, and after it had voided any waste originally in its system it passed nothing more until the test ended after seven days.

Distribution and Requirements

So far, *Helichrysum argyrophyllum* has not been seen west of a line running north from Fort Beaufort. There is a reference in file M4 of the Botanical Survey, Grahamstown, to its occurrence on the farm Stockdale, which is 30 miles north-west of Somerset East in a direct line. Specimens from this farm were determined by the National Herbarium as *Helichrysum splendidum* and *Helichrysum argyrophyllum*, but although I have found *Helichrysum splendidum* on Stockdale, I have searched for *Helichrysum argyrophyllum* without result. The record cannot be substantiated, for the specimens in question were not mounted.

The Helichrysum does not flourish below about 3000 feet. Below this altitude it forms a patchy growth, and even this ceases altogether at about 2500 feet. The unfortunate consequences may be seen in the Mnyameni Valley. There is a carpet of Helichrysum on the upper reaches and bare soil lower

down, with a resulting change in colour from white to red that is clearly visible from many miles away.

In this connection it is, however, worth recording that Dr. Schonland raised from seed and maintained for several years a small patch of *Helichrysum argyrophyllum* in the grounds of the Department of Botany, Rhodes University, where the altitude is about 1700 feet.

Although Helichrysum is a definite xerophyte (page 124), its occurrence on the south-facing slopes of the mountains running west from Mount Thomas shows that it is one of the many which are able to grow under mesic conditions. Usually, however, it is much less common on the mesocline, and the reason for this appears to be that the successionally advanced plants are able to maintain themselves more easily, and after destruction by fire or grazing, to re-establish themselves more quickly under the conditions obtaining there, and by their continued presence they deny the ground to it. Photograph 68 shows how grass remains in the moister hollows after it has been destroyed in the surroundings, and how the Helichrysum in consequence is unable to invade the sward. It will never oust grass unless the grass has been grazed heavily enough to lay bare the soil, and even under these conditions it is merely a temporary stage which will disappear as soon as conditions improve.

It will not exist under the unceasing trampling which takes place round Native settlements, cattle kraals and tracks, and when it goes there is no other plant able to take its place while those conditions remain. This is shown in photograph 69. If it is not kept out by mechanical means there is almost no bare area in the highland sourveld where it will not ultimately grow, and it will germinate and become established on rock, if the surface is cracked or uneven enough to collect a little soil. In heavily grazed areas it persists as a disclimax on all the upland slopes except those facing south, and on all the plateaus. Where the grazing is slightly lighter, even though still excessively severe if judged by generally accepted standards, the Helichrysum is gradually invaded and ousted by the macchia (see photograph 70).

Occurring only as patches on the crests of ridges, or on the bare soil of firebreaks, Helichrysum is rare between Mount Kemp and West Peak Pirie, even though most of the slopes face west and north-west. As these parts are above 4000 feet in altitude and are uncontrolled as to grazing, one would expect Helichrysum to be dominant. The two possible reasons for its unexpected scarcity are set out in the two preceding paragraphs. It was at first thought that the former explanation was the more likely one—that this area, by its nearness to Evelyn Valley with its 70-inch rainfall, might be in a zone wet enough to mask the effect of the sun and give rise to mesic conditions so that the Helichrysum would be suppressed by the resulting vigour of the successionally higher plants. To test this hypothesis, a rain-gauge was set up on the west slopes of Mount Kemp, 30 yards from the summit. The year's readings are given in Table 14, page 23, and show that the area probably lies outside the zone of heavy rainfall, and thus that the theory is untenable. It appears that Helichrysum has given way to macchia according to the latter possibility, and the aerial photographs of 1938 certainly show that the macchia was then far less dense, but whether the cover was grass or Helichrysum in the open parts it is not possible to say.

Control

Burning, followed by resting, will kill the Helichrysum and allow the grass to assume dominance. This was proved by experiment and clearly set out in Schonland's report 21 years ago. Helichrysum is not very inflammable but it is always possible to set it alight unless it is wet from rain or dew. On level ground and in calm weather it smoulders rather than burns, with flame only when there are gusts of wind or where there is an accumulation of trash in the path of the burn. The fire travels very slowly, sometimes less than 2 feet a minute. Generally it dies down of its own accord, for any small barrier in the form of a track or a sparseness in the cover is enough to check its spread. If there is a slope the speed is greatly increased because the draught is more in the direction of the burn instead of at right angles to it, and in such places, or where there is a wind, the fire is a much more extensive and rapid affair. There is always an evolution of dense white smoke with a Helichrysum burn which makes even the small ones conspicuous.

This indiscriminate burning is carried out by Natives during the winter to remove the protective covering of Helichrysum and to expose the remnants of the grass so that the stock may graze them more easily. The resulting seres, in all stages of development, give rise to strange and irregular deviations from the overall pattern of the vegetation which are at first a very puzzling feature of it. Depending on the fierceness of the fire and the subsequent grazing, the old burns may support almost any type of highland community, from sparse Helichrysum to macchia or grassland. Usually they are heavily grazed from the time the new shoots of grass begin to appear, and under this worst possible form of exploitation it is the bare ground that predominates.

When burning is done with a view to re-establishing grass, it is essential that a rest should follow to enable the grass to build up reserves and set seed. Grazing may be allowed in the winter after the seed has fallen, but should be discontinued before the coming of the warmer weather so that the seeds may germinate and the new crop of seedlings become established without hindrance. The rains, and the resulting green growth, make summer burning impracticable and this leaves a choice of burning in early, middle and late winter. Early and middle winter have the disadvantages of leaving the ground uncovered and vulnerable to erosion for too long a time, and of causing an out-of-season greenness which sooner or later becomes blighted by frost. An added objection to early winter burning is the possiblity of destroying some of the grass seed before it has been shed. These difficulties fall away if the burning is done towards the end of winter. It is felt that this should be carried out before the first rains, for the following reasons:—

1. The object is to get rid of the Helichrysum; accordingly a fierce burn is necessary and this is best attained by firing a dry and dormant vegetation.

2. Analyses done by Kotsokoane (ms.) show that Themeda is the commonest grass of the Helichrysum areas, with a basal cover ranging from 8·1 to 60 per cent of the total and averaging 32·3 per cent. Figures for the germination of a strain of Themeda from the eastern Cape (Gluckmann ms.) are as follows:—

	Alternating temps. 95°F day, 65°F night).	*Constant temps.*
Per cent germination after 1 day (24 hrs) ..	0	0
Per cent germination after 2 days (48 hrs.) ..	49	38
Per cent germination after 3 days (72 hrs.) ..	27	53
Per cent germination after 4 days (96 hrs.) ..	4	12
	80	78

From these figures it may be seen that unless burning can be done within 48 hours after rain, there is a risk of destroying the major part of the young Themeda plants by exposing them to fire when they are at their most vulnerable stage.

3. Burning before the first rains has been done at King's Nek, and the results have justified it (see photograph 71).

CHAPTER 4

THE RELATION OF GRASSLAND TO WOODLAND

REVIEW OF LITERATURE

Schimper (1903) and Clements (1905) deal between them with aquatic, woodland, grassland, alpine, arctic and desert vegetation. With the exception of the arctic, all are represented in the eastern Cape, but in their importance woodland and grassland far overshadow the others put together. These two, as Schimper puts it (1903, p. 162) "stand opposed to one another." There is an unceasing tendency for each to encroach upon the territory of the other, and round the margins the balance is often so fine that imperceptible changes will cause one or other of the formations to be over-run. There are forest glades, for instance, and islands of woodland, which in their habitats and their history give no clue to the reason for their difference from the vegetation surrounding them. "The extraordinarily varied nature of the natural and semi-natural vegetation of most parts of the earth's surface, and the extreme complexity of the processes involved in its determination and change, render its correct interpretation a slow and difficult task" (Tansley, 1934, p. 317). This being so, there can be no simple answer to the straightforward question: What conditions favour woodland and what ones favour grassland?

What follows is a summary of the views held by other writers and a collation and a discussion of the facts so far observed at Keiskammahoek.

Clements's concept of the relation between grass and mesophytic woodland is given in his publication of 1934, page 45: "Grassland is preclimax to scrub and forest formations, while these are typically postclimax to it." One may assume that Clements uses the word *scrub* here in its usual sense of stunted tree growth. On pages 43 and 59 of the same publication, however, the word appears to be used in connection with desert shrubs, equivalent to the South African karroo bushes.

This concept was amplified in a personal discussion between him and Mr. R. Rose-Innes, in which Dr. Clements made a point of the strong competition which the grasses offer to the trees in respect of water. He was of the opinion that with a high rainfall, there was enough water for both, and the trees were able to get above the grasses and shade them out of existence. Where there was less rain, the relatively shallow-rooted grasses used the water before it had time to percolate and there was thus a drier subsoil that prevented trees from growing. With a rainfall of less than about five inches a year, trees could live by virtue of their longer roots which were able to penetrate to deep water supplies, but the grasses, unable to reach down so far and with insufficient rain to meet their requirements in the upper layers of the soil, could no longer exist as a formation. From dry to wet areas the picture is thus one of trees, grass and finally trees again. In a joint publication (Weaver and Clements, 1929, p. 460), the idea is expressed as follows: ". . . grassland occupies wide limits between climax forest and xeric scrub or woodland." The depth to which some roots can extend is illustrated by a letter dated 9th August 1948 in file BP 6 of the Division of Botany and Plant Pathology. The writer reports that roots, probably of *Acacia giraffae*, were found at a calculated depth of 150 feet in a borehole in South West Africa.

Clements's correlation of grassland and woodland with rainfall might answer if other factors were equal. As they never are, his hypothesis cannot be applied, at any rate not in a detailed study. This is shown by the fact that five rain-gauges, established in the mountain grasslands above the forests from the Hogsback to Mount Kemp, registered without exception a heavier rainfall than was registered at the forest stations on the same aspect below them (see Table 14, p. 23). Another example is given by Schimper (1903, p. 459) who records that the eastern grasslands of Uruguay and Argentina are moist, with a rainfall of 70–100 centimetres a year (27–39 inches). Further west the country is drier (40–70 centimetres or 15–27 inches) and is under woodland.

It is in addition not an invariable rule that grasses are intermediate between woodland and desert. This has been pointed out by Bews (1929, p. 291).

Clements's correlation is doubtless meant for application on a continental or even a world-wide scale, so large that the anomalies would be lost in the general picture. It is too wide to be considered in any other way.

Another difficulty in his theory is that he does not comment on the life cycle of the desert trees he mentions. It is understandable that they could exist by living on underground water, but it is hard to understand how the seedlings could establish themselves under very arid conditions. The seedlings are the most vulnerable stage of the plant, and the idea of their penetrating great depths of dry soil is manifestly out of the question. However, the fact remains that they do find a way of circumventing this difficulty—not only trees, but other deep-rooted desert plants also. A well-known example is *Acanthosicyos horrida*, an aberrant member of the *Cucurbitaceae* growing in the sandy wastes near Walfish Bay. A description of it is given by Marloth (1932, p. 205), and notes on its life-history are to be found in a paper by Versfeld and Britten (1915, p. 234). Versfeld and Britten suggest that "when a seed germinates in damp soil in which the water gradually subsides, the young roots will naturally extend deeper and deeper in search of water." It is not clear whether their meaning is that the soil is dampened by showers, and that the roots keep pace with this rain-water as it percolates. If this is their meaning, the supposition as it stands is untenable because of the extremely rapid growth-rate which it postulates for the roots, and a modified and more acceptable form of it is advanced by Shreve (1917). From his studies at the Desert Laboratory, Tuscon, he concludes that the establishment of desert perennials is accomplished by their entering a state of dormancy during the dry spells, and by their taking advantage even of meagre showers to put on spurts of growth. Of *Parkinsonia microphylla* he states: "A seedling which has reached a height of 20 centimetres has done so by a fortunate development of its root-system, and by withstanding from 20 to 40 years of the fluctuating conditions of the desert climate." The rainfall at the Desert Laboratory is about 14·60 inches (Shreve, 1914, p. 10).

Michelmore (1939) has made interesting observations on the relations of woodland and grassland in Africa generally. He regards these observations as showing that seasonal or permanent waterlogging of the soil is of prime importance in denying an area to tree growth. This rule is capable of very wide application, and the trees which are not affected by waterlogging appear as a rule to be highly specialised. The most familiar examples are the Taxodium species of the Everglades (Willis, 1919, p. 639) and the *Rhizophoraceae* of the tropical mangrove swamps (Marloth, 1925, p. 222).

Support for Michelmore's observations is provided by Gleason's paper of 1912, which contains a description of a wood seasonally flooded, but with the trees always about two feet above high water mark. Burtt Davy (1922) gives a striking photograph of the Vaal River near Christiana where the same state of affairs is apparent. The trees at the edge of the running water and those well away from it are separated by an open, nearly level belt where conditions are apparently rendered unfavourable to the trees by the lodging of soil water. The work of Griggs (1936) in the sub-arctic Katmai district also shows that trees avoid the poorly-drained soils and grow rather near hillocks, streams or sunken tracks carrying off the water in the immediate vicinity. It is not water in itself, but stagnant water which inhibits tree growth. Perhaps the most convincing evidence is that given by the treeless marshy areas found in the Wolf Ridge forests and described on page 100 of this paper.

But Michelmore's application of this concept to bare plateaus is open to question, for the upland plateaus at Keiskammahoek are rolling, so that the excess water is carried away by a shallow but definite system of drainage lines. On page 295 he states in support of his drainage theory: "Where steep and stony hills arise from such an open plateau, they are nearly always wooded." There are numerous examples of this at Keiskammahoek, and one is shown in photograph 52. The gradient of its sides is roughly 25 degrees. If drainage were involved, it would follow that plane slopes as steep would also support trees, but this is not so. There are plane slopes above the Chatha forests where the gradient is up to 38 degrees, and they are regularly without trees. Michelmore does touch upon this difficulty, and suggests that the soils remain too wet for trees in spite of drainage. This explanation is surely inept if wooded hillocks and grassy plane slopes are found under similar conditions, as the Keiskammahoek examples are. In addition, the aerial photographs show as a general rule that buttress slopes separating wooded valleys are treeless. Michelmore, in claiming that the valley sides are well drained and hence provide suitable conditions for trees, does not explain these bare "knife-edges", which have ground falling away steeply on three sides, and consequently a drainage far more effective than the valley sides where the fall is in only one direction. It is difficult also to reconcile his theory with the almost invariable presence of trees on hills in areas of the karroo which are otherwise under karroo-bush. One might with reason assume that the drainage question falls away here on account of the scanty rainfall in these parts.

The answer is perhaps to be sought rather in Schimper's theory (p. 121) regarding exposure to strong winds, in which matter plateaus, plane slopes and "knife-edges" are most affected.

Phillips (1934, p. 238) states that fires inhibit tree growth, and "the keeping out of fires . . . has certainly resulted in the development of woody scrub of various kinds in South Africa and in East Africa."

Clements (1934, p. 59) reports the opposite from America: "In the great majority of cases, fire increases the dominance of scrub at the expense of grass." It has been pointed out that there is a certain amount of ambiguity connected with Clements's use of the word *scrub*, but here Mr. R. Rose-Innes has been able to confirm that tree growth is meant. He reports a discussion as follows: "Clements says that with the exception of the pines, about 90 per cent of all American trees will sprout again after having been burned down. His statement is that fire increases woody growth, even though it does *appear* to destroy it."

So far, I have found writers on African vegetation unanimous in agreeing with Phillips (1934) that fires destroy woodland, and clear evidence for this theory may be seen in an old burn scar in the Chatha forests, shown on the map and conveniently viewed from the slopes about two miles north-east of the forester's house. A closer examination shows that the original forest trees have been killed, and that the regrowth is not from coppice shoots but from seedlings, a state of affairs in direct conflict with Clements's observations on American trees. There is thus little doubt that African trees, as distinct from those in America, can be killed by fire. Nevertheless, this statement requires qualification. The tests mentioned on page 52 show that the effects of fire on some trees are dependent on the heat evolved, while other trees, like *Xymalos monospora*, survive "enormous forest fires" (Sim, 1907, p. 288), and very little information is available on this subject, particularly in respect of scrub species.

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Another puzzling aspect of the problem is the presence of trees along the railway line between Fort Beaufort and Kingwilliamstown, in spite of the fact that the track is bordered by abundant grass which is set alight at intervals by sparks from the trains. This train service dates from 1904. One cannot blink the possibility that there may be trees which can withstand a certain amount of burning even in the seedling stage, and without experimental data to go by it is dangerous to apply the general rule too widely.

Further evidence for the resistance of the local trees to fire was obtained from a farm in the Fort Beaufort district. A fire broke out on 1st January 1950 on a hillside covered with bush equivalent to woodland type 3. It was extinguished after it had burnt an area of about an acre. The burn was examined on 22nd April 1950. Most of the ground was still bare, some of it scorched black or red, and no seedlings were noticed except one of *Acacia karroo* and a number of a grass which appeared to be *Panicum maximum*. *Oxalis* spp. were regenerating from the underground parts of old plants and not from seed, and were fairly common. Of the trees, a little more than half appeared to have been killed. Nearly all of those alive were shooting from below the surface of the ground, the exceptions noticed being *Euphorbia tetragona* and *Ptaeroxylon obliquum*, which were making new growth from severely scorched trunks. Individuals of the following species were shooting:—

Allophylus decipiens	*Gymnosporia buxifolia*
Asparagus spp.	*Gymnosporia undata*
Brachylaena sp.	*Hippobromus pauciflorus*
Calpurnia sylvatica	*Pavetta capensis*
Commiphora caryaefolia	*Plumbago capensis*
Cussonia spicata	*Ptaeroxylon obliquum*
Ehretia rigida	*Rhoicissus cuneifolia*
Euphorbia tetragona	*Royena cordata*
Fagara capensis	*Schotia latifolia*
Gelonium africanum	*Scolopia zeyheri.*
Grewia occidentalis	

The burn was visited for the second time on 14th February 1951, to see if any regeneration had since occurred from those stumps which had appeared to be dead when the first visit was made. A thick tangle of herbaceous vegetation covered nearly all the ground, concealing all but a few of the stumps. Climbing plants were dominant, and smothered large patches under a luxuriant growth. Common ones were:—

Asparagus spp.	*Melothria punctata*
Coccinia quinqueloba	*Senecio tamoides.*
Helinus integrifolius	

Of the non-climbers the commonest were:—

Atriplex semibaccata	*Senecio juniperinus*
Gnaphalium sp.	*Solanum* spp.
Panicum deustum	*Xanthium spinosum*
Plumbago capensis	*Zinnia multiflora.*

Because of this matted vegetation, it was not possible to make any further observations on the survival and growth of the trees, and only time will tell with what speed and success their regeneration will take place. The preliminary observations, however, make it plain that burning need not necessarily result in their total destruction.

Schimper (1903) goes into the demands of the two formations in greater detail. He defines grassland requirements as:—

1. Frequent rains, particularly in summer. The rain need not necessarily be heavy (p. 173).
2. A supply of superficial soil moisture (p. 173).

3. A mild summer temperature (p. 553).

Hostile to grasslands are:—

1. Summer temperatures by day constantly greater than 86°F or 30°C (p. 173). The English translation of Schimper's work is ambiguous here, and the original German text equally so. One cannot tell from either whether average or maximum temperatures are meant.
2. Drought in spring and early summer (p. 174).

Woodland requirements are:—

1. The continuous presence of a supply of water within reach of the extremities of the roots (p. 166). This, however, is not in accordance with the findings of Rawitscher (see p. 93 of this paper).
2. The predominance of calms over windy weather (p. 555).

Hostile to woodlands are:—

1. Strong winds, especially in the dry season (p. 277).
2. Cold dry winters (p. 456).

CONDITIONS AT KEISKAMMAHOEK

The Forest Climate

An examination of the existing conditions in the Keiskammahoek forests shows that Schimper's theoretical requirements for woodland are met in full. However, his grassland requirements are met no less fully by this same forest climate, and the soundness of his theory is demonstrated by the way the grasses freely occupy all areas where the original forests have been cleared (photographs 23, 28). The layman would naturally and with good reason ask why, since the environment is suitable for both, grassland and woodland do not strike a balance and exist together in the form of parkland. The answer to this question is given by the fundamental ecological law that the climax community of a succession is the one "that terminates in the highest life-form possible in the climate concerned" (Clements, 1936, p. 261). The highest life-form of all is tropical forest, and it is towards this ideal that all successions tend (Wells, Huxley and Wells, undated, p. 661; Bews, 1920, p. 388; Phillips, 1931, p. 204).

Treeless Areas at Low Altitudes

Nevertheless, the forests are not unbroken, nor are the tracts of scrub and bush. There are large areas of grassland below the timber-line, often mixed with trees but usually pure on flats, plateaus and on the tops of ridges (see photographs 72–4). These exposed patches of grassland in otherwise wooded country are the rule in the Union, and there is a note by Aitken (1922, p. 210) on bushy slopes in Natal, with grasslands "on the less steep slopes and on the flatter terraces." The same thing is reported by Rehmann (quoted by Schimper, 1903, p. 601) from south Russia, in the transition zone between steppe and forest. Forests are associated with valleys and ravines, and do not usually go beyond them, and the "large tracts of flat ground that lie between these river valleys and ravines are entirely free from forest." References by Gleason (1912, pp. 38–49) from America indicate that there is a world-wide tendency towards this relationship between the two formations.

In seeking a reason why these particular parts are not wooded, one may safely rule out the possibility of an inadequate supply of soil water. The bare flats round the Keiskammahoek boundary on the road to Debe Nek, for instance, must receive a yearly average rainfall of over 30 inches, if one judges by the Rabula data, and even springs on them are without trees, provided they are not in kloofs or hollows.

The influence of cold dry winters in excluding woodland at lower altitudes must also be considered. Cold is shown to be of minor importance by the presence of trees in dips and hollows and along streams, in the very places where cold air drainage at night would be most likely to cause frost pockets (Whitmore, 1949). If cold were instrumental in encouraging the grass, the gently rounded plateaus and the tops of ridges would be under trees, because such places provide good atmospheric drainage and no lodging-places for the cold air. A very strong argument that cold does not enter into this question comes from areas near the coast. Frosts are a rarity near Round Hill in the Bathurst district, for example (p. 104), yet even here there is the same relation of grasslands to the topography (photographs 4, 5, 72). Bare parts are also unconnected with winter drought, for they occur on level ground even at Evelyn Valley (photograph 73), where the winter rainfall averages over 3 inches a month (Table 13, p. 22). It is therefore unlikely that the winters are cold and dry enough below the timber line to be a force hostile to woodland, and thus the trees probably have no more than the one unfavourable agency of wind to overcome. This is in agreement with their absence in the parts mentioned, which are the ones exposed to the wind's full violence, and with their presence where the country is broken or where isolated boulders provide them with shelter (photograph 75).

Their absence in some of these unfavourable habitats does not appear to be a permanency. It may be not that trees cannot establish themselves in them, but that they establish themselves only with the greatest difficulty. This point is discussed more fully on page 92 and those following.

Treeless Areas at High Altitudes

There is a more or less sudden end to the forests towards the tops of the mountains, an occurrence common throughout the Union, and reported also from tropical Africa by Michelmore (1939). It is extensive enough to suggest that it is not a chance happening and that there is some cause for the general absence of forest trees at the higher altitudes. A consideration of Schimper's woodland requirements indicates that in the matter of water the supply is at least as good as that in the forests themselves, in the winter probably better because of the occasional falls of snow and the frequent mists which are more a feature of the Amatole highlands than of the forests. The highlands, however, are colder and are subject to strong winds. Temperatures are set out in Tables 2–8, pages 8–14; for the winds no figures are available, and reliance is placed instead on observations, and on the established fact that winds are stronger at the higher altitudes (Schimper, 1903, p. 701). It was observed that the highlands were more windswept by far than the lands supporting forest growth. The differences were unexpectedly large. On 23rd January 1950 there was a south-west wind blowing across the Amatole Basin on to the Wolf Plateau. Its force was 6 on the plateau, as measured by the modified Beaufort scale given in the meteorological notebook of the Division of Meteorology. In the Schwarzwald immediately below and to windward, it caused only the slightest movement in the treetops, a force of 3. During a strong wind on 18th August 1949 the wind-force was 3 round the borders of the Chatha forests and at distances 200 yards away and over the force was 7. It is during the dry season that the strong winds are most likely to occur, and it is during the dry season that winds are most unfavourable to forest growth. It is also noteworthy that tongues of forest in protected valleys extend into the mountains far above the general timber-line, and that they extend to the greatest altitudes in the most secluded valleys. According to Schimper's theory therefore it appears as though it may be the cold winter with the accompanying strong winds which keeps out the forests on the upper mountain slopes.

These indications of the injurious effects of wind are supported by the writings of various authors besides Schimper. Beard (1944, p. 144), Belyea (1925), and Maximov (1929, p. 267) emphasise the importance of winds as

desiccating agents. Marloth (1908, pp. 341–6) gives photographs of wind effects, mentioning in his discussion that they sometimes bring about the death of trees. There is a clear picture of wind-pruning in the paper by Griggs (1938, p. 548), and on page 556 he puts forward a strongly supported argument that the cessation of woodland at high altitudes is due almost entirely to wind, stating that severely windy conditions may depress the timber-line by as much as 1500 feet. Braun-Blanquet (1932, p. 157) correlates a number of vegetation boundaries with prevailing winds.

Low-growing plants are also adversely affected. Russell and Wellington (1940, p. 176) quoting Kreutz, state that the growth of cabbages has been increased 300 per cent by shelter from strong winds. As a rule, however, the bad effects of wind are diminished near the ground because the force is less. At a height of 50 feet the velocity is about twice that at 6 inches (Schimper, 1903, p. 76). It is partly as a result of this that grass can continue growing where the wind keeps out the taller woody growth.

Altitudinal Drought

Although in the Border area at least, winds appear to be the greatest influence in denying an area to trees, their mechanical effects are not very severe at Keiskammahoek. The wind-pruning which is so noticeable near the coast is seldom seen, and although a spell of wild weather litters the forest floor with twigs and leaves, and blows down some of the older trees, there is never any wholesale destruction of the forests. Even on the exposed highlands the winds are seldom strong enough to cause breaking or uprooting of the macchia, and some of the macchia grows up to 12 feet and more. It is mainly as desiccating agents that their effect is felt, for they cause "a vast increase in transpiration" (Schimper, 1903, p. 168). It does not at first seem possible that winds could offset the advantages of the obviously well-watered Amatole highlands, with their abundant streams and large marshy areas and their cool and misty climate. It must however be remembered that the mountain winds are more violent, and that the parching winter winds in particular, which reach gale force at times, are in their effects likely to be most unfavourable to the growth of forest trees. Such winds can produce rapid wilting even with adequate soil water (Maximov, 1929, p. 286). In addition, they are aided by other forces, and their combination gives rise to a habitat which, free water notwithstanding, becomes in effect dry at certain times. Probably the first to apply this concept of drought induced by altitude was Schimper (1903). He clearly recognised its existence even though he did not have at his disposal all the facts which physics has since made available to later workers.

An important influence is the frost, which is a commonplace above the forests during any winter. The freezing of the soil is mentioned in the chapter on climate. Like hot dry soils, cold wet soils give rise to physiological drought (Warming and Vahl, 1909, pp. 194–5), and this drought increases with a lowering of the temperature until the soil water freezes, at which point soil moisture becomes totally unavailable to plants. The matter is discussed also by Maximov (1929, pp. 85–6) and Beard (1944, p. 133).

This is not to say that high temperatures do not come into the picture as well. They plainly do, and their telling effect is apparent from the increased numbers of xerophytes on the high northerly slopes (photograph 38). Temperatures are correlated with solar radiation, which is intensified at high altitudes becauses of the rarified atmosphere which allows a freer passage to the sun's rays (Schimper, 1903, p. 701). This factor is regarded by Maximov (1929, p. 154) to be of paramount importance in its effect on transpiration. It is particularly strong on the xerocline, being proportional to the light, which increases with the angle of incidence of the sun's rays. As to the actual rate of increase, opinions vary. Clements's figures (1905, p. 59) are:—

Angle of Incidence	*Light*
10°	17 per cent
90°	100 per cent.

Robbins, quoted by Aitken (1922, p. 209), gives:—

Angle of Incidence	*Light*
10°	33·4 per cent
90°	100 per cent.

Plants may be able to avoid the effects of solar radiation to a certain extent by setting their leaves with their edges towards the sun. It is however not known to what degree the local ones do so, if in fact they do so at all.

Bews (1917b, p. 525) remarks that evaporation at higher altitudes is greatly increased owing to the diminished atmospheric pressure. It is likely that this may be connected with increased transpiration, but as the relationship is complicated by other factors (Maximov, 1929, p. 169), the likelihood has not yet been made a certainty.

The highland soils have a peaty character. There is general agreement among the authors cited by Maximov (1929, p. 89) that such soils are physiologically dry.

The effect of all the influences mentioned grows with the height above sea level so that the habitat becomes physiologically drier the nearer it is to the tops of the mountains. Compensation from heavier rainfall has effect only up to about 5000 feet, thereafter there is scarcely any increase with the altitude (Whitmore, 1949b). This may explain the observations of Staples and Hudson (1938, p. 7) that the rainfall in the Basutoland mountains was lower than they had expected, even taking into account the snow, and the fact that most gauges were in valleys.

The atmospheric humidity has an important influence on transpiration (Maximov, 1929, p. 154), and the mountain air is moister than that of the lowlands, as Figure 1 shows. But from this same figure it appears that the mountain air may be surprisingly little moister, and Michelmore (1947) reports similarly that there are only small differences in atmospheric humidity near evaporating bodies of water and far from them.

XEROPHYTISM

General

Before considering the effect of the highland climate on the vegetation, it is advisable to discuss the term *xerophyte*, and a few of the characteristics of xerophytes. The word having been used loosely by many writers, notes have been written by Thoday (1933) and Carpenter (1938) in an attempt to bring order to the confusion. The definition given by Maximov (1931, p. 282) is followed in this paper: "Xerophytes are plants of dry habitats, which are able to decrease the transpiration rate to a minimum when under water deficiency." They are distinguished by their capacity to survive long periods of drought and dehydration of their tissues without injury, or with only slight injury (Maximov, 1929, p. 281), but their transpiration is not of necessity low at all times, and many of them can and do transpire heavily when circumstances permit.

Although they are xerophytic, they need not necessarily be xerophilous. They may be forced out of wet habitats simply because of the competition of more vigorous mesophytic plants, and not because moisture is harmful to them. One might cite in illustration a parallel case from the animal world. The Bushmen are today found only in the wastes of the Kalahari, but this race is not precluded from living in the moister regions by anything more than the fact that it has been exterminated there.

Before Maximov's work was generally known, it had been assumed that transpiration in xerophytes was always low, no matter what the habitat conditions might be, and so firmly established was this theory that Maximov's work was at first scouted by many physiologists. In the evidence he presents in support of his theory, Maximov omits one very pertinent point, perhaps, after direct experimental proof, the most telling one of all. The point is that it is a law of nature that organs which are not used by their owners become in the course of evolution functionless and vestigial. This is discussed at some length by Wells, Huxley and Wells (undated, pp. 232–5, 268). For this reason, if xerophytes were plants in which the transpiration was always low, they would be likely to conform to the law by having fewer or degenerate stomata. Instead, they have a plentiful supply, fully functional, which may be protected by various intricate mechanisms from rapid desiccation. To put it anthropomorphically, if their object were to reduce transpiration, it would seem strange that xerophytes should go to the labour firstly of producing stomata and secondly of protecting them. This behaviour, however, is explained if one accepts Maximov's view that xerophytes uncover their stomata and transpire heavily when they have the opportunity. It is to their advantage to be able to do so when they may, for the anabolism of all the higher plants is bound up with their transpiration.

Morphologically, xerophytes are usually characterised by one or more of the following:—

Development of strengthening tissue in the leaves	(Salisbury, 1949, p. 517)
Rolling of the leaves with stomata inside	(Maximov, 1929, p. 61)
Hairiness	(,, p. 262)
Ericoid leaves	(,, p. 264)
Waxy covering	(,, p. 392)
Thick cuticle	(,, p. 392)
Succulence	(,, p. 392)
Reduction in size of leaf cells, and strongly developed venation	(,, p. 327)

As Illustrated in the Amatole Mountains

The last character was not investigated, but the frequency of the other characters in the vegetation of the Amatole range unmistakably confirms the severity of the mountain climate. At times, naturally, conditions are mesic, for example on the calm, warm days which so often follow the summer rains, and it is then that the tolerance of the xerophytes prevents their being harmed by the copious supplies of available water.

Succulence is shown by species of Crassula, Delosperma and allied genera, but this character is more pronounced in the drier parts of the Fish and Keiskamma river valleys. On the mountains, hairiness and ericoid leaves (with which is usually associated rolling of the leaves with the stomata inside) are the commonest characters, so much so that the others are entirely insignificant by comparison. *Helichrysum argyrophyllum* alone makes up 100 square miles of densely hairy vegetation in the Amatole mountains (White, 1948). That *Helichrysum argyrophyllum* has increased enormously in the past 50 years does not alter the fact that the mountains are its natural home. It was collected by Ecklon, probably on the Katberg, about 1830 (Schonland, 1927, p. 6; MacOwan, 1886, pp. xliv–xlv), and it is accompanied by something like 55 other species of its genus (Sim, 1894), all more or less hairy.

The area under ericoid vegetation (macchia) is at Keiskammahoek roughly three times that under Helichrysum, and the leaf-structure of *Erica brownleeae*, *Cliffortia paucistaminea* and *Cliffortia linearifolia* is shown in Figures 8–10. In *Erica brownleeae* the adaxial side of the leaf has very thinly scattered and short unicellular hairs, arising as projections from the epidermal cells. No stomata were seen on this side. The leaf being strongly revolute, the abaxial side is tucked away below the leaf edges, and it is in this sheltered channel that the stomata are found, additionally protected by a dense felt of epidermal hairs three or four times longer than those on the opposite surface. The stomatal apertures are minute, so much so that it is most difficult to find them in a transverse section. They are more easily located by stripping the epidermis, in spite of the trouble presented by the smallness of the leaf and the depth of the abaxial channel. The leaf is sensitive to changes in humidity, and sections placed dry under the microscope will alter shape and tend to straighten if breathed upon. The mechanism by which this is brought about is not immediately apparent. As the leaf dries, the edges come closer together and the hairs meet and interlock, and in this way the stomata become more and more cut off from currents of dry air. The adaxial side of the leaf has the epidermis divided by a septum running parallel to the surface.

The leaf of *Cliffortia linearifolia* is very like that of *Erica brownleeae* in shape and anatomy. There are similarly a few protuberances on the adaxial side and longer thickly crowded ones in the abaxial channels, but even the longest are little more than slight projections from the epidermal cells, so heavily cutinised that the central lumen is all but obliterated, and they are too short and broad to be classified as hairs. The structure is touched upon in a general way by Eames and McDaniels (1925, pp. 36–7). As the stomata are found in the channels (Weimarck, 1934, p. 168), the projections fulfil the same protective function as do the hairs of *Erica brownleeae*.

In *Cliffortia paucistaminea* the stomata are on the sides of the leaf (Weimarck, 1934, p. 169), although morphologically still on the abaxial surface, and they are protected by precisely the same type of projection as is found in *Cliffortia linearifolia*.

Except where the stomata occur, the leaves of all three species have a thick cuticle, which is a further xerophytic character.

It is often stated that macchia requires a winter rainfall, but this is not strictly correct. It is summer drought, lack of water in the growing season when it is most needed, which causes conditions too severe for forest and allows the less demanding macchia to grow.

An interesting xerophytic grass from the Katberg and Winterberg is *Danthonia disticha*, the leaf-structure of which is shown in Figure 11. There are no stomata on the abaxial side of the leaf, on the contrary there is a heavy lignification and a thick covering cuticle, suggesting that the loss of water through this side is negligible. Turning to the adaxial side, one finds that the folding of the leaf cuts off this surface from communication with the atmosphere except through the narrow slit which separates the margins of the leaf, and that the stomata are further protected from drought by being set in deep recesses. Nor is this the only device to guard against desiccation, for there are unicellular hairs which project across the recesses and interlock and which one may safely assume are able to reduce the movement of air currents to something very small indeed. At the bottom of each recess are several large epidermal cells with thin walls and an irregular shape. They resemble closely the cells described by Haberlandt (1928, pp. 559-60) in the leaves of certain xerophytic grasses, and probably fulfil the same function of folding or opening out the lamina according to the spells of dry and wet weather.

Festuca costata is another widely distributed xerophytic grass, occurring in extensive patches throughout the Winterberg and Amatole ranges (photograph 76 and Figure 12). It usually grows in quantity only from an altitude of 5000 feet upwards, and thus in the coolest and wettest part of the mountains. Its leaf, which is flat in wet weather, becomes tightly revolute when it is dry and by this means effectually cuts off all its stomata from the open air, for they are found only on the adaxial side, which is the inner face of the spiral. A

secondary protection is afforded by the ribbing, which breaks up the adaxial surface into a great number of channels containing the stomata, shallow and wide when the lamina is flat but deepened with its rolling and narrowed to the merest slits. Three of four large epidermal cells in rows at the base of each channel probably have the same function as in *Danthonia disticha*. Cutinisation is heavy on the abaxial side and light over the assimilating tissue. All these characters, together with the strong girdles of sclerenchyma in the ribs indicate that this grass is excellently fitted to weather the droughts and high winds of the mountain ranges.

Danthonia disticha is common along the tops of the mountains forming the escarpment from the Aberdeen to the Victoria East districts, and is found mixed with the *Festuca costata* and *Themeda triandra* which constitute the veld type of the Drakensberg range from the peaks down to about five or six thousand feet above the sea. In places it is one of the most important grasses (West, 1951, p. 49). By referring to the vegetation map of the Union (Acocks, in press) the distribution of these grasses may be seen at a glance, and the presence in quantity of two pronounced xerophytes over the huge area of 8000 square miles on South Africa's most important catchment is the strongest possible support for the concept of altitudinal drought.

If the climate is dry, physiologically or otherwise, both below and above the mesic forest belt, why are the grassland and woodland species in these two dry zones so different? There are two answers to this question. Firstly, the difference is not quite as great as it appears at first sight, for some species do grow in both zones. There is a list on page 92 of the trees which have been found growing above the timber-line on the Amatole mountains, and it is repeated here with those marked accordingly which occur in the dry lowlands as well.

Bowkeria sp.	
Buddleja auriculata	
Buddleja salvifolia	karroo (Sim, 1907, p. 277)
Canthium ciliatum	
Cassine kraussiana	collected Alicedale (Cruden, 252)
Cassine tetragona	
Cussonia paniculata	karroo and semi-karroid scrub (Sim, 1907, p. 230)
Euclea undulata	frequent in the semi-karroid scrubs (Sim, 1907, p. 263)
Gymnosporia acuminata	
Gymnosporia buxifolia	on karroo kopjes (Sim, 1907, p. 186)
Halleria lucida	on karroo kopjes (Sim, 1907, p. 281)
Heteromorpha sp.	in the thornveld (Sim, 1907, p. 229)
Kiggelaria africana	in the karroo (Sim, 1907, p. 128)
Myrica sp.	
Osyris compressa	collected mountain above Commadagga (Burchell, 3327)
Podocarpus latifolius	
Rapanea melanophloeos	
Rhamnus prinoides	karroo kopjes (Sim, 1907, p. 179)
Rhus dentata forma *genuina*	Bothas Hill (Schonland, 1930, p. 38)
Rhus pyroides	various forms recorded from hot and dry places (Schonland, 1930, pp. 29–31).

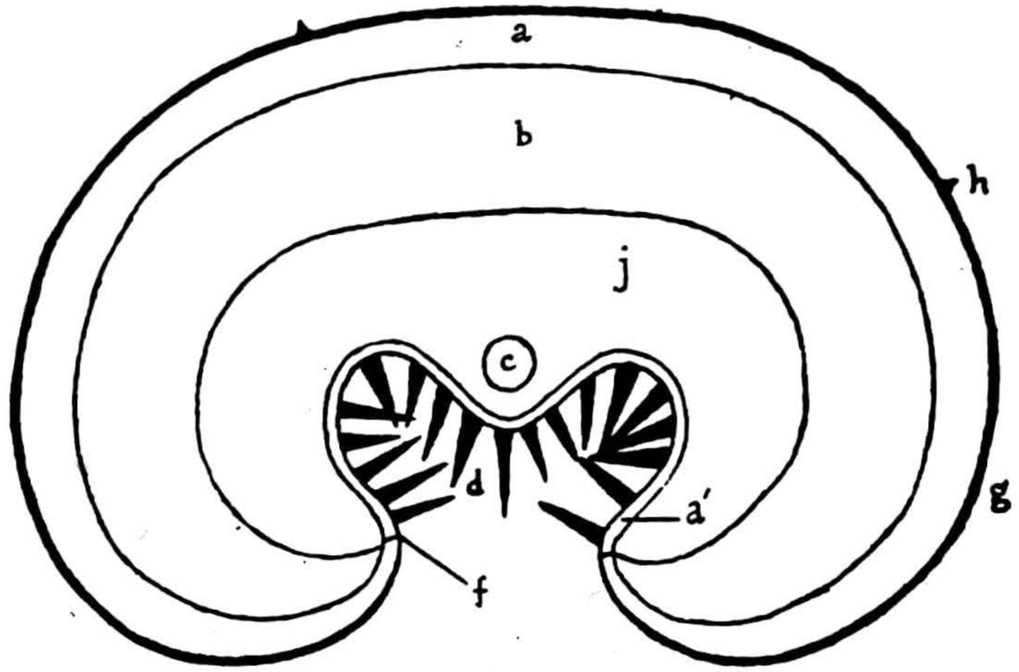

Fig. 8—Transverse Section of Leaf of *Erica brownleeae*. (Magnification 150).

a. epidermis, divided by a septum into two layers
a'. epidermis of smaller cells produced into long and narrow projections
b. palisade parenchyma
c. vascular tissue
d. recess in which stomata are situated
f. junction between lower and upper surface of leaf, marked by changing structure of epidermal cells
g. cuticle
h. scattered epidermal projections
j. mesophyll.

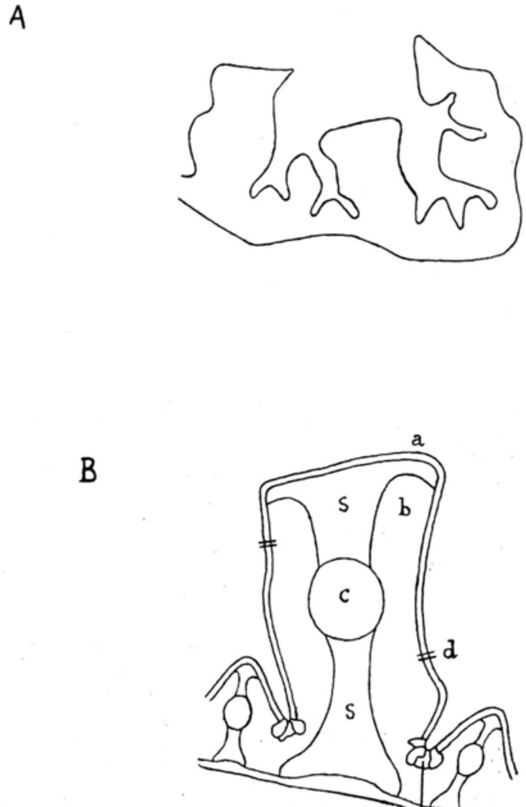

Fig. 12—Transverse Section of Leaf of *Festuca costata.*

A. Magnification 130, to show the shelter given by the broken nature of the upper surface

B. Magnification 300
- a. epidermis
- a′. modified epidermal cells of large size and irregular shape
- b. mesophyll
- c. vascular tissue
- d. stoma
- s. sclerenchyma.

Danthonia disticha provides another example of this double distribution, for it also is found in the karroid scrub. There are extensive patches of it growing among the karroo bush six miles from Grahamstown on the Cradock road, and it is recorded as well from similar country on the Fish River Rand, near Fort Brown.

Both woodland and grassland, then, have representatives in the two dry zones. That there are not more of them is probably because of the second reason, namely the temperature differences in these same zones. The influence of the temperature on the flora is mentioned on page 31. It is noteworthy also that the observation that thorniness is related to dryness (Bews, 1927, pp. 67, 75; Phillips, 1931, p. 135; Dyer, 1937, p. 90; Wells, Huxley and Wells, undated, p. 598) needs amplification. A *cool* and dry habitat is not characterised by thorny species. A *hot* and dry one is.

Macchia and Grass

Bews (1916, p. 145) subscribes to the view that grasslands are less mesophytic than bush, and this has been shown experimentally by McGinnies and Arnold (1939, p. 245). The physiological drought which has been discussed gives one an explanation of the cessation of forest growth on the higher slopes, and of the abundance of the grasses. The water-balance is more difficult to maintain, and the grasses can continue growing there because they are more xeric than the forests. This makes it clear that Clements's correlation of grassland and woodland with rainfall is in the right direction. It would, however, have been more readily understandable had he correlated the formations with available water, which may be a very different thing from rainfall.

But it is not only grass which grows on the Amatole highlands. The vegetation here is a patchwork of communities of macchia, grass and Helichrysum, and one is faced with the task of sorting out their relations with one another. The Helichrysum has been studied by Schonland (1927) and White (1948), who have shown that it is an invader which replaces the grasslands wherever they have been destroyed by over-grazing. It is thus merely an artificial community, and may be looked upon as potential grassland. This reduces the communities under consideration to two, namely grassland and macchia, and simplifies the work in hand. In their respective needs these two communities were found so closely akin that some difficulty was experienced in correlating them with the habitat factors. There follows a discussion of the points so far observed.

Firstly, there is a well-marked tendency for the grasses to linger on the xerocline long after the succession on the mesocline has reached the macchia stage. This may be clearly seen by an examination of the aerial photographs, and is also shown in photograph 77.

Secondly, the exposed and wind-blown places (plateaus, ridges and rounded hilltops) are usually more thinly covered with macchia, and have a correspondingly thicker grass cover than the steeper or more broken ground. This is evident throughout the highlands and is particularly well shown at the top of the right of way between the Wolf Plateau and the eastern boundary of the plantations of the Wolf Ridge Forest Station. The path leads out of the forest through a steep macchia-covered slope, and opens on to a plateau where the vegetation is open (Figure 13 and photograph 78).

Another clear illustration is at the top of the main Chatha valley, where a number of ravines under dense macchia are separated by grassy buttress slopes.

Thirdly, the water requirements of macchia are greater than those of grass. Grassland areas often contain localised wet patches where the water supply is sufficient for the growth of stands of macchia. Photograph 41 shows communities of *Erica brownleeae* covering the seepage areas below rock faces.

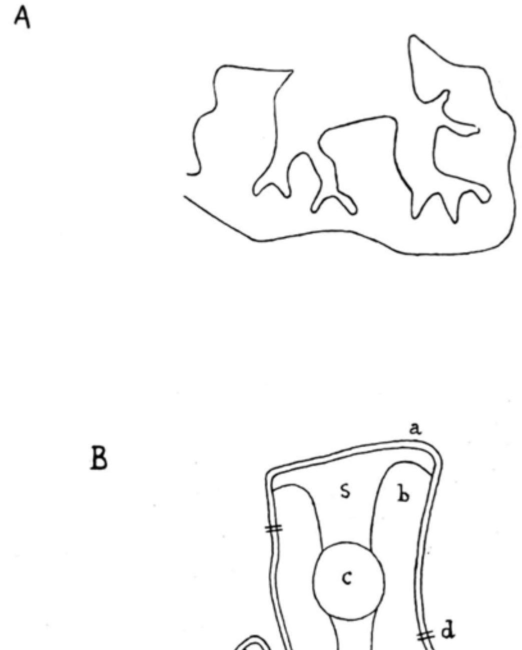

Fig. 12—Transverse Section of Leaf of *Festuca costata*.
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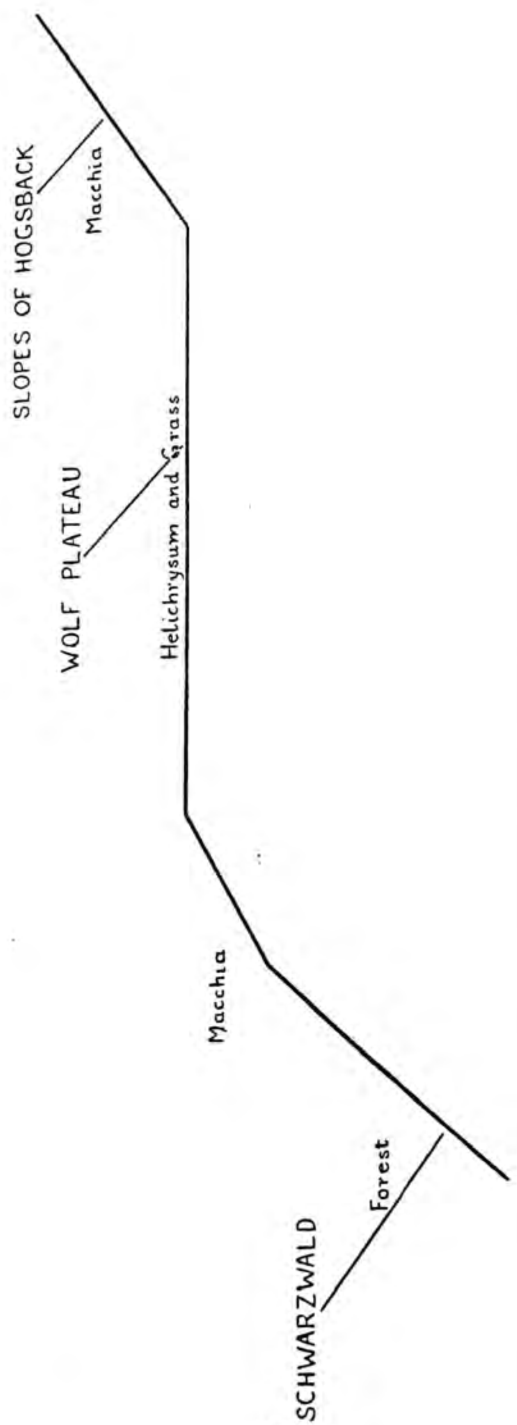

Fig. 13—Diagrammatic Section running North and South through the Wolf Plateau. (Not to scale).

Warming and Vahl (1909, pp. 210–11) also consider grass to be the more xeric formation of the two.

Fourthly, fire destroys macchia and encourages grass (page 90).

Fifthly, all the indications are that grass is in these areas low in the succession and a seral stage leading to macchia. The evidence for this has been fully discussed in Chapter 2, under the section dealing with type 7.

The General Picture

The points discussed in this chapter lead to the following conclusions: South of the escarpment the forests occupy a zone which has a mild and wet climate. Below the forests the climate is hot and dry, and the vegetation thorny scrub. Above them the climate is cold and *in effect* dry, and the vegetation is macchia. Grass tends to occupy the wind-blown flats, ridges and plateaus in all three climatic zones. It is sourveld in the forest zone and above, and sweetveld below. In its essentials, the pattern of the vegetation is thus seen to be a symmetrical one, the forests being the centre of the system, and being flanked on either side by shorter woodland which has grass in its drier areas.

If the Amatole mountains continued upward to about 10,000 feet, the increasing severity of the climate would be likely to inhibit the growth of macchia, and grass, the more xeric type of vegetation, would probably be the climax. It is significant that in his account of the Drakensberg vegetation West (1951, p. 50) reports that at the summit (which is over 10,000 feet in altitude) "the macchia shrubs probably excluded by periodical fires are conspicuously absent". It may well be, however, that the highest parts are out of the macchia zone, and if this is so, West's alpine grassland is not a subclimax, but a climax. Marloth (1901, p. 163) reports the same disappearance of arborescent shrubs on the mountains of the south-western Cape. Here their limit is much lower, in the region of 4000 feet. In countries further south it is lower still. Dorrien-Smith (1908, p. 241) describes the Auckland Islands, south of New Zealand, as "heights 2000 feet high, in dense foliage up to 600 feet, and then a low scrub, till the grass line is met at 800 to 1000 feet".

To return to the Amatole mountains—if they continued higher, there would come a zone beyond which even the grasslands would be unable to extend, and where one would be likely to find the strongly xerophytic rosette plants, succulents and Helichrysum species that are now present among the rocks on the edge of the escarpment. These would continue up to the line of perpetual snow.

A brief description has been given on page 113 of the grasslands on the northern side of the escarpment. In the lack of definite evidence, it would be rash to assume that they are the climax in this region, but it can be confidently stated that they have a strong hold upon it. Macchia is absent, probably because of a combination of factors contributing towards the maintenance of a dry habitat. Baker (1944, p. 227) has shown that the rainfall is greatly reduced on the mountain slopes facing away from its direction of incidence. Sometimes the effect may be so sudden that the edge of the rain shadow coincides with the crest of the mountain, and the readings from the Mount Kemp raingauge (Table 14, page 23) suggest that this rule may be applied at Keiskammahoek as well. Potzger (1939) found that there was, in Central Indiana, 61 per cent more evaporation on the xerocline than on the mesocline. Where the slopes are gentle, as these ones are, there is little protection from wind. Gentle slopes permit also the lodging of cold air at night, whereas steep slopes give rise to rapid cold air drainage and consequently warmer conditions (Aitken, 1922, p. 208). Aitken's investigations (pp. 213–4) showed moreover that on the xerocline there was a slightly higher air temperature (higher by 6°F) and that the maximum soil temperature at two inches was twice as high and the holard half as high as it was on the mesocline.

Under these extreme conditions, macchia and forest are on the north slopes of the Amatole range found only where rocky outcrops present shelter favourable for their growth, and even then they are represented by nothing more than a few bushes and one or two species. As the river valleys deepen towards the north, the increased shelter and warmer climate permit the development of communities of mixed scrub and Acacia similar to those found in the lowlands to the south of the escarpment.

Figure 14 is a diagrammatic section running north and south through Keiskammahoek to show the relation of the communities with the climate.

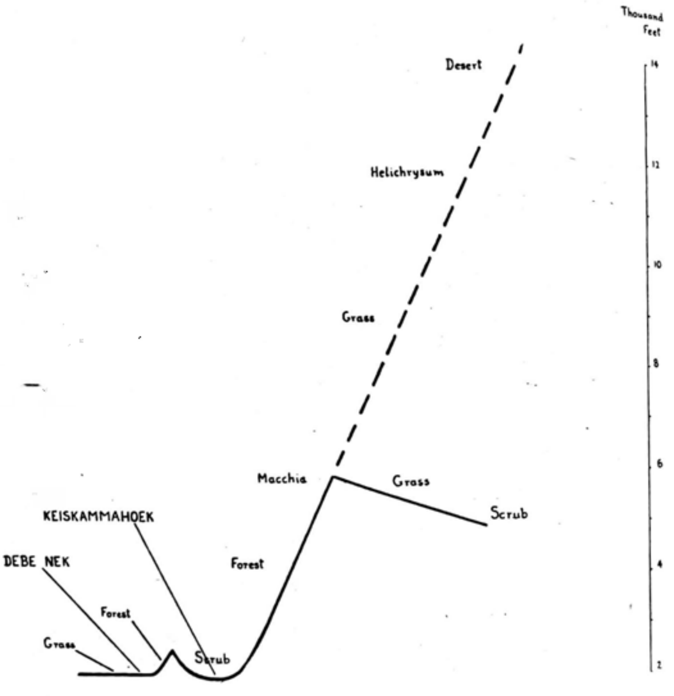

Fig. 14—Diagrammatic Section running from the Lowlands to the Highlands. Dotted slope hypothetical. (Simplified, horizontal scale reduced).

The vegetation map of the Union (Acocks, in press) shows on a much larger scale the same relation. It is best seen in the Transkei where there is no irregularly broken topography to complicate the climate and vegetation. The moist strip along the coast is Subtropical Coastal Forest. Above it in order are a strip of Coast Thornveld, the Highland Sourveld, which extends as far as the Drakensberg, and the Themeda-Festuca Alpine Veld of Basutoland. According to the evidence presented in this paper, these four veld types are in order of increasing xerophytism from the coast inland, and the underlying reasons appear to be as follows: The high rain and shelter in the Coastal Forest zone are each less in the Coast Thornveld (see Department of Irrigation rainfall map). In the Highland Sourveld there is as compared with the Coast Thornveld no great lessening of the rainfall, but the rolling country and the consequent exposure to wind make the habitat unfavourable for forest growth except where the hills provide shelter. On the Basutoland mountains the altitudinal drought exerts its influence, and here the most xerophytic type of the four is dominant. There is no anomaly presented by the Themeda in the alpine vegetation, for it is a very tolerant grass. It is recorded from most of the Union, including the dry western Orange Free State, with a rainfall of less than 15 inches.

Some workers are strongly of the opinion that the Highland Sourveld was originally temperate forest and that it has been destroyed by man. If the theory is accepted, the strip of Coast Thornveld presents a serious difficulty. Thorn is generally acknowledged to be a drier type than both Subtropical Coastal Forest and Temperate Forest. Why then would it be sandwiched between the two? There is no evident reason for this as far as the rainfall is concerned. Underlying geological formations may influence the vegetation (Mogg, 1929), but Prof. Mountain of Rhodes University informs me that there are no geological formations in this area which correspond even roughly with the Coast Thornveld. The strip of thorn presents a difficulty not only to those who hold the opinion stated, but likewise to those who regard thorn as a more xeric type of vegetation than grass, and for the same reason: why, in a reasonably even climate, would there be a strip of dry vegetation between two wet ones? That the thorn might develop into forest is beside the point, for its present relative abundance indicates that the area suits it better than do the areas towards the coast or those further inland.

The relative needs of grass, thorn and forest are clearly seen within a small area at Round Hill (p. 104). The disposition of the three communities is shown in photographs 4, 5 and 72. Woodland occupies the slopes of the hill only, the cooler south slopes being under dry forest and the northern ones under *Acacia karroo*. Assuming that Acacia is the most xeric community, one would logically expect to find a gap, under grass, between the Acacia and the forest, but the ring of woodland is unbroken. The grass is dominant only on the top of the hill and on the flats at its foot, and the evidence presented indicates that they are drier habitats than the slopes of the hill. The facts suggest strongly that the communities in increasing order of dryness are forest, thorn and grassland.

Present Trends

All the woodland types are on the increase at Keiskammahoek except if the trees are being felled or if very heavy stocking is the rule, and more detailed notes on this tendency are given in Chapter 2, where the types are considered separately.

The Macchia

As far as the macchia is concerned, it has been shown that the increase n the highlands is very likely to be the re-establishment of a climax which has been destroyed by fire, and that below an altitude of about 4000 feet it is often a seral stage leading to forest.

The Scrub

Some workers have put forward the theory that scrub is increasing because of a climatic change towards drier conditions, and Wicht's figures (1949), which include the Evelyn Valley records, do show a downward trend in the

South African rainfall. This theory, however, postulates that scrub is a more xeric community than grass, and reasons have been given to show that the postulation is unlikely to be correct. An additional difficulty in the theory that scrub encroachment is bound up with decreasing rainfall is the contemporaneous spread of high forest, even in the face of a certain amount of grazing (see page 139).

If the reason *is* climatic, it may be sought rather in the season of the rainfall than in its decrease, undoubted though this may be. Possible causes of a shrinking of grassland and an advance of woodland, as given by Schimper (1903, pp. 174, 492, 548), are a dry early summer and thereafter irregular rain interrupted by dry periods. If there has been any change of this nature, however, it has not yet been proved.

Clements attributes the spread of Prosopis in the drier North American grasslands to the weakening of the grass competition through uncontrolled grazing. Evidence for a parallel in South Africa is given in the discussion of type 1 in this paper.

Although, as Dyer (1937, p. 55) has pointed out, the different kinds of game in the early days would have had a far bigger variety of tastes than the few kinds of domestic stock, their extermination does not account for the spread of woodland, for it has been reported from the Kruger National Park by Wolhuter (1948, p. 121). He states that Pretorius Kop during the Boer War was "not unlike the highveld" and was dotted about with fairly large trees, and that there has been a great increase of scrub since then, and of Dicrostachys in particular.

To sum up, the only acceptable theories for scrub encroachment are a change in rainfall seasons (for which, however, there is no direct proof) and heavy and uncontrolled grazing. Conditions in the Kruger Park cast some doubt on the grazing theory, but perhaps the balance between the animals has not yet become re-adjusted, for it was at first the policy to limit the carnivora without checking the game. Stevenson-Hamilton (1937, p. 270) states ". . . it is possible that the overstocked position today, which of course would not have occurred had normal rains fallen after 1925, might have been considerably ameliorated, and lions and other beasts of prey no more numerous than they now are, had we refrained, during the long period of twenty-five years, from conducting the 'thinning out' process". He states also (pp. 268, 270) that "of recent years, probably because they were affected by some canine disease, the wild dogs (Lycaon pictus) have almost disappeared from the southern regions of the Park, while the impala have increased so much that they have, in many cases, completely outrun their food supply, and have spread into areas formerly considered to be unsuitable to them . . . If wild dogs still existed in the numbers they did thirty years ago, I believe the impala would be in better condition, if less plentiful than they are".

The relation of grassland to scrub at Keiskammahoek was investigated as follows: On the ridges south-east of Burnshill are a number of old sneezewood stumps up to 24 inches in diameter. Figures kindly supplied by the Conservator of Forests, Kingwilliamstown, show that the fastest growth so far observed for sneezewood is an annual girth increment of 0·375 inches in the Alexandria forests. With this figure as standard, it may be calculated that the minimum age of the stumps is about 200 years. From the remnants of such old trees, and from the prints done by Bowler in 1864 of Fort Cox and Burnshill, which show the unbroken dominance of the scrub on the hills, it appears safe to take for granted that dry scrub or forest is the climax at Keiskammahoek wherever there is a broken or rugged topography to give shelter from wind.

These, however, are not the areas directly concerned in this discussion. Those that are, and that present most difficulty in interpretation, are the exposed

positions (favouring grass) which from photographic and historical evidence used to support few trees or none, and where invasion by woodland is the rule (photographs 10, 11).

The absence of protected areas in such places presents great difficulty to the worker who is studying the succession. The tests of a climax, as set out by Weaver and Clements (1929, pp. 422–3) are of uncertain meaning. Apart from accurate historical records, there seems only one certain way of proving what the true position is, and that is by camping an area which will be guarded against fire and subjected to strictly controlled grazing. Complete protection from grazing is unnatural and will produce an unnatural result (Bews, 1929, p. 69; Weaver and Clements, 1929, p. 392; Story, 1939, p. 337; Henkel, 1947). To investigate the successional position of encroaching woodland, sites have been fenced near Grahamstown and at Keiskammahoek, in grassland, thorn scrub and mixed scrub, but as no conclusive evidence can be expected from these plots for many years, the best that can be done in the meantime is to discuss the rather fragmentary evidence that is available.

Here and in similar places the successional position of the scrub could be one of the following:—

1. It may be the climax. If so, these places are its true home, and it was growing there in quantity long before the Bantu arrived. The most obvious difficulty in this theory is to find an answer to the question: what caused the scrub to disappear? The influence of fire has been suggested, although it is usually expressed indirectly by the statement that the increase is due to the suppression of fires (Wolhuter, 1948, p. 121; Phillips, 1934; Galpin, 1926, p. 80). Fires in the early days did undoubtedly occur in the lowlands. An account of a fire in the lowlands of the Bedford district is given by Ainslie (1899, p. 136) as follows:—

> ". . . Spring Grove homestead was burnt in the 'sixties'. That was a most disastrous fire. It was a very dry season; the forest got ablaze and a strong wind spread the fire over the whole valley. The house had been re-thatched after the war; it caught fire, and the family had to take refuge in the middle of the ploughed land. Only the mill-house escaped the flames, nearly everything else being lost."

It has, however, been pointed out that the effects of fire upon dry scrub are still not fully known (page 119), and even on the assumption that fire does destroy scrub completely, it is reasonably certain that slopes would have suffered more than flats if it had been the agent, for the reasons given on page 116. Yet the Keiskammahoek slopes are under dense scrub today, and have been so for generations.

It has been suggested also that the Bantu cleared the scrub from the most accessible areas for cultivation or for fuel, or to provide for pasture for their cattle. Bews (1917) suggests that the thorn scrub round Pietermaritzburg is regenerating after having been felled for firewood, and Sim (1907, p. 49) gives historical evidence to show that Acacia has vanished over parts of the Transkei because of felling. Nevertheless, this cannot reasonably be extended to cover the whole Union because of the huge areas involved and the sparseness of the population in many parts of those affected, and even with the aid of the most modern machinery, scrub clearing is an arduous and costly undertaking. Were it otherwise, there is little doubt that the Addo bush and allied formations, which are close to the largest city in the eastern Cape, would have vanished long ago, and that the scrub encroachment which is now under discussion would never have become a problem. Moreover, it is taking place in parts which were never under intensive Bantu settlement, for example in the Albany district, which in the eighteenth century was sparsely occupied by a tribe of Hottentots (Hewitt, 1920, pp. 27–31). Except for marauding parties, it was not until 1779 that the Bantu crossed the Fish River (Tooke, 1905, p. 386), and their stay was short, for the "Zuurveld" (the Albany, Bathurst and Alexandria districts) was cleared of Natives in 1811 (Cory, 1920, p. 7).

In many parts of the sweetveld the scrub growth extends from the hillsides in conspicuous ribbons down the lengths of small watercourses. As the watercourses are often too shallow to give the slightest protection from woodcutters or fire, neither can be held responsible for clearing all the surroundings of scrub and leaving these vestiges. The only apparent reason for them is the better water supply and shelter from wind, and the only apparent reason for their absence in the grasslands is the relative lack of both these influences.

The indications are that there is no satisfactory explanation for the original destruction of the scrub. From this it follows that the concept of a scrub climax where scrub is now encroaching must for the time being be treated with reserve. Conflicting evidence is presented in the extension of the Keiskammahoek cemetery, which has been protected for 61 years (Jubb, 1945). Grazing is occasional and there is no burning or cutting of the grass, yet in spite of this scrub species do succeed in establishing themselves, although rarely, as those responsible for the upkeep of the cemetery unanimously maintain. I have noticed (in 1950) one plant each of *Gymnosporia buxifolia* and *Acacia karroo*, in height three feet and one foot respectively. Both are growing in disturbed ground, apparently the sites of old termitaria which are broken down during the routine tidying of the cemetery. Kotsokoane (ms.) reports two additional seedlings of *Acacia karroo*.

2. It may be subclimax to grass. This means that it is lower in the succession than grass and hence more xeric, for the succession advances from xeric to mesic types of vegetation at Keiskammahoek with negligible exceptions. This possibility may be dismissed as extremely unlikely, for reasons already given.

3. It may be post-climax to grass, that is, it may have affinities with the forest. If so, it is more mesic than grass, and an intruder into grassland, which is under normal conditions too dry for it. Its present increase may be explained by the lack of grass competition (pages 28, 50).

4. It may originally have formed an open woodland, with grass between the trees. Possibly it is a misapplication of the law cited on page 121 which has caused among some ecologists a certain reluctance to accept the idea of a wide and stable community of trees and grass, and a tendency to seek as a reason for its presence a change in the original vegetation, caused by a changing climate or a disturbance by man or stock. For example, Bews (1916, p. 150) states that there are two views as to its origin: either the trees are "remants of a previously closer type of bush" or they are an "initial stage in bush succession". There does not, however, appear to be any reason why a climate should not be deficient in characters essential to the vigorous growth of grassland, and deficient at the same time in the ones essential to that of woodland, or why it should not be extensive and stable. Under the conditions described, the climate would be partly suitable for both, and trees and grass might be expected to grow together in a stable community, neither gaining the ascendency because a deficiency would prevent its becoming dominant. The term "tension belt" for a transition zone is perhaps an unfortunate one, for there is tension between the members of any community with the possible exception of those in deserts.

From the evidence as a whole, it is not possible to make a definite statement, but it is suggested tentatively that the odds are in favour of possibilities

3 and 4 (a scrub post-climax or an open woodland climax). There is not enough evidence at present to carry the argument past this point.

The Forests

A spreading of the forests has been reported from the high-rainfall regions of North America by Brown (1941) in an account of the vegetation of Roan Mountain, where the successional trends appear to be essentially similar to those of the Amatole mountains. The forests are interrupted by grassy spaces known as balds, which are coming under shrubby Rhododendron and Alder and changing finally to Spruce-Fir forest. Brown, giving several reasons for doing so, rejects the theory that they are Indian clearings, and states that the problem of bald origin is not yet solved. He considers that the present tree encroachment may be because of a change in climate. It is interesting that Rhododendrons should in North America play the same part as that played by the macchia at Keiskammahoek, for the Ericas which are such an important component of the macchia, and the Rhododendrons, are in the same family. Solereder (1898, pp. 481-2) reports that they also have the double leaf epidermis similar to that of *Erica brownleeae* and *Cliffortia linearifolia*. An excellent illustration of highland Rhododendron in North America is given by Macbride (1950, pp. 24–5).

Along the borders of the Keiskammahoek forests also, encroachment on the grasslands is steadily taking place. It is a mistake to regard the high forests as unstable communities barely able to reproduce themselves and liable to vanish unless left strictly alone. Their natural vigour is illustrated rather clearly at Cwencwe Forest Station, east of Evelyn Valley, by their encroachment on a grassy hilltop. In 1912, trig beacon 14 Cwencwe was established on this hill, and a recce report by J. B. Don, dated December of that year, states "... the beacon will be found in a corner of a grassy angle running into forest". Mr. H. A. Ruddock, of Trigsurvey, Kingwilliamstown, allowed me to extract the following note from his report on the beacon, dated 4th August 1946 and headed *Report on Tertiary Recce: Area 32/27MP14 Kingwilliamstown:*—

"It is situated 42 feet inside the perimeter of an extensive indigenous forest, consisting of enormous trees probably well over 100 feet high . . . I managed by cutting undergrowth to make the secondary point 23 FRANKFORT and the proposed tertiary MPAHLANA visible. By extensive felling of large trees, the secondaries 92 WIESBADEN and 3 BALAZIE could possibly be made visible, but I do not think this is practicable. In my opinion, 14 CWENCWE is quite useless."

Unless one stumbled upon it by accident, one would be put to a great deal of trouble to find it, for although the lane cut in 1946 is still open, the gloom inside the forest is too deep to allow the beacon to be seen easily from outside. I visited it on 13th October 1950, and was fortunate in obtaining the help of the forest foreman at Cwencwe, Mr. W. R. Cloete, who was able to go straight to the spot. The distance between the beacon and the edge of the forest was approximately 27 feet, measured to the stems of the last mature trees. Mr. Ruddock has informed me that the discrepancy between this distance and that given in the recce report is probably a matter of interpretation. He may have taken into account the canopy or the seedling trees. The three secondary points mentioned in the report were already established when Don visited the beacon, and were presumably visible from it at that time.

Cliffortia linearifolia, *Cliffortia paucistaminea* and *Erica brownleeae* are all growing on this hill, but only sparsely, the grasses being everywhere dominant outside the forest. There is no screen of shrubs or bush on the forest margin, which is here abrupt and appears to be advancing directly on the grassland through scattered seedlings. In other parts (page 79) the encroachment is often through macchia.

Except in detail, the spread of the Keiskammahoek forests is taking place in the same way as that of the scrub, and with minor adjustments according to common sense the same arguments apply, namely that climatic change or uncontrolled grazing may be responsible for the spread, and that the forests are post-climax on many of the exposed situations where they are now encroaching. The theory, applicable to scrub, that they once formed an open woodland on these places is not acceptable, for unless they have been thinned artificially, forest trees do not form open woodland. The theoretical reason for this is probably best grasped by picturing a patch of forest in a central favourable habitat, surrounded by concentric zones where conditions are progressively less favourable. It is suggested that where the zones tend towards heat and aridity, the forest gives way to thorny scrub, and it is this that forms a parkland before the pure grasslands are reached. Similarly where the zones tend towards high winds and cold the forest gives way to macchia, which forms a parkland giving way to grasslands. There is an example of a macchia parkland on the farm Fort Merriman, on the road between Stutterheim and Keiskammahoek, and near the boundary between the two districts. It is made up of widely-scattered trees of *Protea multibracteata* (photograph 85).

CONCLUSIONS

Macchia is apparently the climax above the forests and between them, with grasslands on the most exposed parts. Its encroachment is normal and it is doubtful whether any system of grazing will stop it. Its regrowth will continually have to be checked by fire or by mechanical clearing.

The scrub is probably post-climax where it is now encroaching. The significance of this is that if these areas are protected from uncontrolled grazing, they should remain grassland with sound grazing systems alone, and without artificial aids.

CHAPTER 5

ECONOMIC BOTANY AND POINTS OF GENERAL INTEREST

LAND USE

GENERAL

Houghton's studies in the Keiskammahoek district (in press) have led him to conclude that "the only means of survival of the present population is for some members of the households to seek to earn a livelihood outside the reserve and to support those remaining behind by remittances". That under present conditions the land is carrying more people than it should is shown also by the devastation in the mountain and lowland pastures, the new areas of cultivation appearing on progressively steeper slopes and the shrinking of the unprotected forest patches because of damage by stock and woodcutters.

It is generally accepted that good methods of land use can greatly increase production, among these methods being controlled grazing, scrub clearing, irrigation, the use of fertilisers and weed-killers, and the bringing of more land under cultivation by means of contour banks and terraces, and there is no doubt that the district could support more people than it does, and support them without the deterioration of soil and vegetation that is at present going on. This, however, may not be the complete solution to the problem. History shows that there has been a very large increase in the population during the last hundred years (page 146), and although one cannot with certainty predict a like increase in the future, the possibility is one that should not be summarily dismissed. For this reason, any plan for restoring and maintaining the productivity of the vegetation and the land in the district should take into account the difficulties which will inevitably occur if there should be increasingly heavy demands made upon them. The disastrous consequences of ignoring the rise of population in the past are mentioned on pages 145–8. It would seem most unwise to repeat that mistake. While it is not suggested that planning should be extended to cover the remote future, it does nevertheless seem advisable that planners should look a great deal further ahead than has in the past been thought necessary, and that the potential length of time before mankind should not be entirely lost sight of. Wells, Huxley and Wells (undated, p. 274) and Jeans (1948, p. 134) have some interesting remarks to make on the last subject.

SWEETVELD

In the sweetveld as a whole, there is little erosion that calls for large-scale conservation engineering, what donga erosion there is being small enough to be dealt with by hand. Such methods include checking the flow of water by barriers of stones packed according to the method used by Pentz in parts of the Drakensberg Reclamation Area, establishing vegetation across the beds of dongas, for which purpose American aloe is outstanding, and protecting eroded areas from grazing during the time they are recovering. The details of all these methods are known to the officials of the Native Affairs Department, and advice, if needed for more comprehensive schemes, could be obtained from the Extension Officer at Kingwilliamstown, and from engineers in the Government service. For these reasons, it is felt that a full discussion is unnecessary in this paper.

Less spectacular, but with more serious consequences, it is sheet erosion which does most damage at Keiskammahoek, and until the grazing can be controlled there is little that can be done to stop it. Resting, followed by controlled grazing, is all that is necessary to bring back the cover, for the local veld has a marvellous capacity for recovering after ill-treatment even when the top-soil is gone. This is also well known to the municipality and the Government officials, who have obtained striking results in reclamation in various badly-denuded parts in the sweetveld.

Considerable parts of the river round the town have straightened their course and become wider since the old picture postcards were printed in 1912. This process is faster than it should be along most of the rivers in the lowlands and could be greatly slowed down if grazing and cultivation were prohibited within even as little as 20 yards from the water's edge. Such protection would put a stop to the breaking away of the soil from trampling and ploughing, and the resulting margin of vegetation would check the eroding action of the water when the rivers were in flood. These benefits are recognised in Mauritius, where a law requires that every stream shall be guarded by a strip of undisturbed vegetation (Schonken, 1930, p. 211). Locally, there would no doubt be legal difficulties in the application of the scheme, and compensation to be paid to the riparian owners.

There are about 30 square miles of comparatively valueless thorny scrub in the lowlands that could be eradicated to make way for pastures with a higher carrying capacity, the results that may be obtained by this means having been clearly shown by Mr. E. D. Matthews on the farm Tukulu, near Alice. The first necessity, however, is fencing, for strict grazing control is necessary after clearing, particularly where the scrub is dense and the grass cover consequently thin. Great harm may be done by removing even noxious vegetation if heavy grazing permits nothing to take its place, and it is suggested that until the cover is normal again, grazing should be done in the winter only, to allow seeding to take place unhindered. The difficulties of scrub clearance are likely to be lessened in the near future by the development of the new and promising chemicals which are at present in the experimental stage. Reseeding of the veld by hand is not recommended at present, for there are no areas of sweetveld in the district or in its neighbourhood which could provide more than a very meagre supply of seed, nor is there sufficient information about the germination of the local grasses to warrant its application on a large scale. The labour involved in planting grass roots and the uncertainty of the results make this method out of the question as well, except where urgently needed to stop erosion. Subdivision, controlled grazing and adequate watering-places for stock are essentials too well known to call for discussion.

Apart from relatively small areas, the sweetveld is not generally suitable for agriculture by reason of the heat, the low rainfall and the rugged topography, and it is thus important that advantage should be taken of every favourable influence. The possibilities for irrigation need to be explored, and it seems advisable also that attention should be paid to the aspect of cultivated lands, for the dry type of vegetation which grows on the northern slopes is everywhere in contrast to the moister type on those facing south. Although examples may be seen alike in the most advanced and the most primitive stages in the succession, whether in the highlands or the lowlands (photographs 38, 81, 82), this fixed rule has found little application in the agriculture of the district, arable lands, even where the owners have a choice in the matter, being located nearly always for convenience in ploughing, and in disregard for the effects of the climate. I have found no published figures correlating yields with the aspect, but from the examples occurring in the natural vegetation, it would appear to be a sound recommendation that arable lands should be located on the south slopes wherever possible.

SOURVELD

The high rainfall in the sourveld is apt to give a wrong impression of fertility and general suitability for agriculture, but the climate is in many respects unfavourable to plant growth, as has been pointed out in chapter 4, and the highland soils are in addition generally poor and acid (Scott, 1949, pp. 14, 62). Moreover, because of the importance of the highlands as a catchment area, and their steepness, it is not advisable to allow cultivation there until the people are much further advanced agriculturally than they are at present. There appears no objection, however, to the utilisation of the highlands as a grazing area, provided it is done under supervision, and subject to certain provisions which are to be mentioned.

There are about seven square miles of Helichrysum in the sourveld and more macchia that could be converted to grass and brought under controlled grazing, and these pastures could play a most important part in the maintenance of the stock because of their potentially heavy yields. As they afford poor winter grazing, they could be used to the best advantage by being grazed in summer. It is unlikely that they will ever contribute much of value towards winter feeding because the topography prevents the use of the mower except on the Wolf plateau and a few smaller areas, and there are thus not many possibilities for making veld hay.

As over much of the highlands the protection afforded by Helichrysum and macchia prevents both donga erosion and sheet erosion from becoming serious, it is in localised areas rather than on the highlands as a whole that damage is taking place. The firebreaks round the forests for example are regularly cleared of vegetation, and at present there appears to be no alternative to this unfortunate necessity. In many parts of the Chatha firebreaks, and on those near Mount Thomas, erosion is becoming a serious matter. It is suggested that rough contour banks, such as could be made and maintained by unskilled labour, might be a cheap method of halting a great deal of the harm.

Photograph 80 shows the damage that can be done by the practice of dragging timber from the plantations to the loading point. Where the slopes are steep and the danger greatest, trouble could probably often be avoided by rigging a cableway for the purpose. Sleighs cause similar damage wherever they are used, and attempts should be made to discourage the use of them and to obtain the co-operation of the people in this matter.

Tunnel erosion, which has been dealt with in a paper by Henkel, Bayer and Coutts (1938) and appears difficult to cure, is occasional in the Helichrysum areas. The extensive surface erosion occurring in the Mnyameni Valley, and caused by heavy trampling, has been mentioned on page 114.

Some of the most vulnerable areas, although they are at present under grass, are the lands above Chatha Forest Station. They are very steep (slopes of more than 32 degrees have been recorded) and their soils, being peaty, are not only easily washed away but are also susceptible to wind erosion (Bosazza, 1950). This is one of the steepest and hence least accessible parts of the district, and has so far escaped destruction. Photograph 67 shows that hungry cattle are agile enough to reach almost every part of these mountains, and it is recommended that the north-eastern corner of the Chatha ministerial grazing be closed to stock except only in times of emergency. The rest of the Chatha ministerial grazing should be sub-divided and the movement of stock strictly controlled. This is obviously true of all the pastures in the district, but it is emphasised here because of the shallowness of the soil, the steepness of the slopes and the importance of this particular part as a catchment area, the source of the Chatha River. It should have priority in fencing materials, and a very close watch must be kept upon the grass cover. Next in importance are the upper reaches of the Mnyameni Valley and the land north of Dontsa Forest Station, also considerable catchment areas and heavily stocked.

A beginning has already been made with the fencing of the seepage areas where the mountain streams have their source. This work is doubly necessary, firstly because the seepage areas bear a different vegetation from their surroundings, and because it is one of the principles of controlled grazing that fencing should be done according to the vegetation. Secondly, cattle have the habit of loitering in and around them during hot weather, with consequent damage to soil and vegetation (see photograph 79).

The extensive areas under macchia, and their importance in protecting the sources of the Amatole streams, make it necessary to consider carefully any points for and against it before any schemes are undertaken to destroy it and establish grass in its place.

The widely-held view that shrubs and trees cause a greater precipitation on the area they cover than would otherwise occur has been discredited by the investigations of Fourcade (1942). It is hence doubtful if a cover of macchia has any advantage over one of grass in the maintenance of a steady flow of water in the catchment areas. In the matter of soil protection also, there is little to choose between them (see page 84).

Thus for soil and water conservation, which, as Professor Robb has often pointed out, is the primary function of vegetation, the two formations are of approximately equal value. It is in the secondary function, the providing of fodder, that the grasslands are incomparably more valuable. "One plant family, the grasses, is of greater importance to man than all the other approximately three hundred families of flowering plants put together" (Hitchcock, 1929, p. 133). At Keiskammahoek, however, there are under present conditions practical objections to the grasses, for grassland means grazing, grazing without control means erosion and ruined land, and control is impossible without fencing material and the co-operation of the people. Where grazing cannot be controlled, macchia has a decided advantage in that it affords with time an increasingly effective barrier to stock, and catchment areas are safe from damage in all places where the community has become mature. From the practical point of view it has one serious defect, for as soon as the community approaches maturity it is threatened by the constant possibility of fire, and when an area of dense macchia has been burnt the ground remains bare much longer than it does after a grass fire.

In spite of the disadvantages of macchia, the abuse of grassland constitutes so serious a menance to the people of the district and to others who are dependent upon the Amatole water, that it is recommended that attempts should not be made to bring macchia areas under grass unless there are facilities for the strict control of grazing. It should be borne in mind also that although there is no doubt of ultimate success except where there is heavy infestation with Rubus (photographs 48–51), the conversion is a long and tedious process where the macchia is dense. The best method in densely overgrown areas would probably be to burn parts along the contours in rotation, season by season. This would ensure that the run-off would be checked by strips of vegetation instead of being allowed to rush unhindered down the slope, and that the fire would be kept to manageable proportions between the firebreaks. To obviate the regeneration of macchia from seed washed down from communities above the burn, it would be necessary to burn the strips in descending order.

It is not possible to estimate with accuracy the number of times the rotation would have to be carried out before the grass became dominant, because the circumstances in each area are different. The ideal of clearing the macchia thoroughly and maintaining the grasslands by controlled grazing alone is unlikely to be attained. In the first place, as macchia appears to be the climax formation in the sourveld, it will tend to invade the grasslands whatever their treatment may be, and in the second, the highland macchia is not as palatable as the lowland macchia is (page 83), and the grasslands are bound to be damaged before it is eaten, particularly where Erica is concerned. The principle of the occasional use of fire must be accepted in any scheme which aims at the efficient use of the mountain vegetation in its secondary function of beef production as well as its primary one of soil and water conservation.

It has been mentioned (page 85) that one cannot burn dense macchia without leaving the soil practically bare of vegetation. Reseeding might with advantage be tried in such bare areas once the rest of the veld had recovered sufficiently to supply the necessary seed. Themeda becomes plentiful when Helichrysum is removed, and seed from reclaimed Helichrysum areas (which are usually less rugged) would be fairly easy to collect. Its germination is as a rule good (see page 116).

Introduced grasses have been tried in the sourveld by Dyer. Details of the trials are recorded in the files of the Botanical Survey Section, Grahamstown, and a summary is given in Dyer's paper of 1929. In September and October 1927, a square in the north-west corner of Schonland's plot, in area one acre, was thoroughly prepared by ploughing, harrowing and cross-ploughing. The following grasses were planted on 18th February 1928:—

Arrhenatherum elatius	*Digitaria smutsii*
Beckeropsis uniseta	*Echinochloa pyramidalis*
Brachiaria ? mutica	*Festuca elatior*
Bromus catharticus	*Panicum maximum*
Cenchrus ciliaris	*Pennisetum purpureum*
Chloris gayana	*? Phalaris tuberosa*
Dactylis glomerata	*Setaria aurea.*
Digitaria eriantha	

Some showed promise, but the Arrhenatherum, Bromus, Dactylis, Festuca and Phalaris were failures and were replanted on 18th and 19th of February 1930. As there was no vestige of any of them in 1947, it may be concluded that it would be unwise to try converting macchia areas to artificial pastures without comprehensive trials beforehand.

The land under Rubus and Stoebe is extensive enough to justify an investigation into methods of dealing with these two pests. At present no satisfactory method of control is known.

THE MINISTERIAL GRAZING

The ministerial grazing is ground which belongs to the Department of Forestry and is leased to the Natives for grazing on the understanding that this is a privilege and not a right. The total area is about 5600 morgen.

There are a little over 8000 cattle in the district, which number would appear inadequate to the needs of the 17,000 people. As the grazing grounds which the Natives possess are under present conditions insufficient to support even this inadequacy, the ministerial grazing is of the utmost importance to them. Its history may be pieced together from the correspondence and reports in the files of the Department of Forestry, Kingwilliamstown, and dates from 1853, when the Gaikas having been expelled from what is now the Keiskammahoek district, other Natives were settled in the area by Sir George Grey. The newcomers were people who could be depended upon not to take up arms against the colonists and were probably chosen to act as a buffer between them and the Natives of less predictable behaviour further to the east. Mr. A. E. Jubb, formerly Magistrate at Keiskammahoek, has stated to me in a personal letter "Various portions of the district were surveyed into 10, 20 and 40 acre lots, and granted to individual Natives in terms of a British Kaffrarian Ordinance and subsequently under Cape Law Tenure acts, either in freehold or quitrent tenure, and ample and adequate areas provided for grazing." There was plenty for everybody, and commissions visiting the district between 1882 and 1888 reported that "ample provision has been made for all requirements of the people both for agricultural and grazing purposes". It cannot be said whether the members of these commissions ignored the difficulties which the coming generation would have to face. Probably the abundance of land and the sparse population blinded them to what was coming. Conditions then and now may be judged from the following extract from a report by Dr. A. W. Burton (1950). The reference is to farms in British Kaffraria, which according to Hall (1856) was the country bounded by the Keiskamma, the Kei and the Klipplaat Rivers. "At the second sale in 1879, 71 farms whose total extent was 57,262 morgen realised the low sum of £2819. The largest of the farms—2054 morgen—was sold for £30. One buyer secured eight farms whose total extent was 5687 morgen for the paltry sum of £252." The price of land in those areas today, as indicated by advertisements in *The Farmer's Weekly*, is somewhere in the neighbourhood of £20 a morgen, and the census figures from Dr. Burton's paper show that the population of all races has risen from 64,212 in 1859 to 185,652 in 1946.

With respect to Keiskammahoek, Mr. Jubb's letter continues "No one reckoned on the natural increase of population, the unreliability of the chiefs of the various sections, who allowed more people to come in from adjacent districts and settled them on the commonage, or the fact that beacons (and fences) are anathema to the Native; with the result that the grazing areas are today in some, if not all, locations reduced to an enormous extent. You will find that locations like Wolf River, Rabula and Lenye have practically no grazing areas today because of squatters. When Mr. E. D. Beale demarcated the locations in about 1924, he found that there were no less than 2400 squatters on the commonage".

Only in 1909 was an agreement drawn up regarding the grazing on crown land. It is probable that this took place when the destruction of the grazing grounds had made it abundantly clear that something would have to be done. The date marks also the stirring of public opinion on the matter, as is shown by a minute, dated 2nd March 1935, in the Department of Forestry files referred to: "Eminent ecologists, irrigation engineers, the Botanical Survey Committee, forest officials, magistrates, individual farmers' associations and farmers' congresses and others have from time to time during the past twenty-five years drawn attention to the state of the veld and of the forests on these mountains resulting directly from overgrazing and trespass and bad methods of cultivation". A leader in the *Daily Dispatch* of 23rd August 1927 mentions that there was anxiety about the grazing 20 years earlier (1907).

If the public noticed the damage in 1909 or thereabouts, it is reasonably certain that deterioration had already been in progress for a number of years; and the abundance reported before 1890 together with the adverse reports after 1910 point to the beginning of the century as the likely turning-point in the composition of the veld.

The idea of the agreement of 1909 was a sound one, but the number of flaws became increasingly apparent as time went on. Many of the clauses were not observed and could not be enforced, with the result that the Natives gradually began to regard as their right not only certain privileges but also things which they had undertaken not to do. There was in addition doubt whether the headmen consenting to some of the agreements in the name of the people had been legally empowered to do so, and doubt whether they had signed in accordance with what the people wished. It was contended too that the implications of the agreements had not been fully understood at the time of signing. Although some of the arguments may have been specious, the contents of the

files satisfy one that in general the Natives were sincere in their conviction that their inalienable rights were being encroached upon when the State began to do what it was entitled to do in terms of the agreement, and to fence in land for protection or for establishing plantations.

That the Government was in a legally unassailable position did nothing to ease matters, and the bitter resentment of the Natives may be judged from the fact that two lost their lives when they were involved in a fracas with Government employees who were carrying out their duty in enforcing some of the regulations. The grazing fees were twice allowed to get into arrear, and what looked like serious trouble was averted only through the tact of the officials most closely concerned.

A further cause of resentment arose from the fact that some of the beacons had in the course of time become lost or obliterated, so that areas had to be demarcated again, at times with a good deal of uncertainty.

The broad picture is an unhappy one of a diffuse policy in the beginning with the inevitable attendant difficulties in the shape of endless bickerings and compromises. An agreement was reached in 1938 whereby the South African Native Trust undertook to pay the ministerial grazing fees on condition that it should have control over the grazing system to be followed. The following extract from the Keiskammahoek District Record Book is of interest in this connection:—

"On the 26th of April 1939, the Chief Native Commissioner advised that an arrangement on the following lines had been concluded with the Director of Forestry:—

1. That the ministerial grazing leases in this district should be taken over by the Trust, the Trust to pay the yearly rentals at present rates as well as arrear rentals.

2. The Trust to fence along the perimeter of the grazing areas and to sub-divide, likewise by fencing, the areas into suitable rotational grazing paddocks.

3. The Chief Native Commissioner, in consultation with the Conservator of Forests, King William's Town, to limit the number of cattle to be depastured from time to time in the various grazing areas.

4. As its contribution towards the cost of such fencing the Forestry Department will supply the Trust with the necessary fencing poles, free of charge. In the event of termination of the arrangement all material in the fence except the poles will remain the property of the Trust.

5. In carrying out the fencing, small areas of forest land will, where practicable, be cut into the grazing camps so as to provide the necessary shelter for the cattle in winter. Similarly, small compensating areas of grassland will be cut into the forests and utilised as reserves for the growing of thatch, for which there is a great demand on the part of local Natives.

6. No further land in these grazing areas will be withdrawn from pasturage and utilised for afforestation.

7. Leases will be on a yearly basis as at present and arrangements will be subject to termination on six months' notice on either side, subject, however, to the consent of the Native communities who at present hold these leases.

During January 1939 the Native Commissioner held meetings with the Natives, who agreed to the proposals, and the following agreement was signed by the headmen respectively and a number of their councillors:—

'We, the undersigned, being duly authorised thereto by the residents of the .... location in the district of Keiskama Hoek, do hereby agree that the grazing area known as the .... Ministerial Grazing Area be taken over and controlled by the South African Native Trust, hereinafter referred to as the Trust, on the following terms and conditions:—

1. That the Trust will pay the prescribed grazing fee to the Forest Department.

2. That the Trust will fence the grazing area, thereby also fencing off patches of forest and creating thatch reserves and that, where convenient, small portions of forest be cut into the grazing area as shelter for stock.

3. That the Trust be empowered to conduct rotational grazing and when necessary to limit the number of stock on the grazing area, and to close one or more of the fenced paddocks to allow the grass to seed, or for the purpose of combating Helichrysum.

4. That the grazing area be sub-divided into fenced paddocks, and as far as possible each with its own water supply.

5. That no goats be allowed on the grazing area.

6. That the Native Commissioner or his deputy be empowered to impound any stock found on the grazing area in contravention of paragraphs 3 or 5 hereof.

7. That the burning of grass will be prohibited except with the permission of the Native Commissioner.'

NOTE: As the result of overstocking in the past, the entire area of the ministerial grazing leases is badly affected with Helichrysum and 'Fynbos' and is now scarcely worth anything as a grazing area. Endeavours have been made to persuade the Natives to voluntarily eradicate Fynbos in order to permit recovery of grass, but with little success; the Gwili Gwili people have risen to the occasion and done what was required of them; the Mtwaku people did perfunctory work in the Mount Thomas camp only; people of the other locations have been promising to follow the lead of Gwili Gwili but have not as yet done anything."

PLANTS OF ECONOMIC IMPORTANCE

The native timbers are described so adequately by Sim (1907) that no additional notes are necessary in a general report of this nature. In the Crown forests at present, only dead or moribund trees may be felled and for this reason the forests fall into the category of what Sir John Russell (1949) terms "unused land", a misnomer, for they are being used, and that to the best possible effect—as a protection for the catchment areas. Both from the materialistic and the aesthetic point of view, no amount of money would compensate for their destruction. The trade in timber at Keiskammahoek is done mostly by the coloured people, who buy the trees from the Forestry Department and do the felling by hand. Unseasoned planks are sold locally, *Olea laurifolia* and *Podocarpus* spp. being the species most in demand.

Medicinal plants and fodder trees are disregarded in this paper for they have been dealt with by Watt and Breyer-Brandwijk (1932) and Dyer (1937) respectively. Those plants showing possibilities as garden flowers and ornamental trees are also disregarded. The subject is too large to be attempted here.

Sim (1894) lists just under 2500 species of plants in Kaffraria, and the uses to which they could be put are almost completely unexplored.

The list which follows contains notes on those few about which there is at present some information, and includes also the poisonous plants which have been observed. Detailed information on a few of these poisonous plants is given by Curson (c. 1926), and fuller information on nearly all of them by Steyn (1934). They do not appear to cause many losses in the district in spite of the abundance of some. The plants of minor importance, both useful and harmful, have not been dealt with. Many that bear wild fruits fall into this category, the fruits being in the strict sense of the word edible but of little use except as novelties.

Acacia karroo. Its uses have ben enumerated in Chapter 2.

Acokanthera spp. Poisonous. It is uncertain whether two species are involved, or two forms of the same species. They have been recorded from woodland types 4, 5 and 6, and are plentiful in the forest patches along the waggon track running southwards to the plateau above Debe Nek.

Aloe arborescens. Often used to make a strong and quick-growing hedge (photograph 84). An effective barrier to stock and at the same time excellent as a windbreak. Plentiful round the lower forest margins.

Aloe ferox. Yields the drug "Cape Aloes". Schauder (1949, p. 99) states that the demand for it is unsatisfied, and that the price to producers is at present about sixpence a pound. Notes on its collection and preparation, and references to the literature on it, are given by Reynolds (1950, pp. 466–8). *Aloe ferox* is, however, not common in the district. It occurs mostly near Fort Cox.

Amanita muscaria. Used as a fly poison and as a narcotic (Marloth, 1913, Vol. I, p. 23). Occasional in all pine plantations.

Amaranthus paniculatus. Widely used by Natives as a green vegetable, and particularly valuable as an anti-scorbutic. According to the *Flora Capensis* it is "cultivated in many warm countries for its grain. In India it supplies the staple food of hill tribes over a large area".

Asclepias fruticosa and *Asclepias physocarpa.* Poisonous. Widely scattered.

Asparagus spp. The young shoots of several species are edible. Widespread.

Aster filifolius. Poisonous in some areas, in others regarded as a useful fodder bush. Plentiful in denuded parts near the lower margins of the sourveld.

Azima tetracantha. Taints milk. Common in woodland types 2 to 5.

Bobartia gracilis. Discussed on page 97.

Boophone disticha. Poisonous. Usually found round the upper limits of the sweetveld, but uncommon.

Calodendrum capense. Sim (1907, p. 154) reports that the seeds contain oil, but that they are too bitter to be edible. In woodland types 4, 5 and 6, occasional.

Cassine kraussiana. Poisonous. Described under *Cassine capensis* by Steyn (1934, p. 605). Recorded from woodland types 4 and 6.

Catha edulis. Narcotic (Davison, 1927, p. 339). Rare (page 152).

Chrysocoma tenuifolia. Poisonous, but not consistently so. In some parts it is considered a useful feed. It does not appear to affect cattle. Widely distributed.

Combretum salicifolium. The nectar contaminates honey by giving it a taint and an unpleasant smell. It is a stream-bank species found only in the sweetveld.

Commiphora caryaefolia. The wood is not durable but as the tree grows easily from truncheons it is used to make live fencing poles. Recorded from woodland types 3, 5 and 6, frequent where hot and dry, otherwise uncommon. Sim (1907, p. 159) considers that there are two species of Commiphora, the key characters being the number of leaflets to the leaf, but the work of Wild (1950, p. 120) suggests that the number of leaflets may depend on the rainfall.

Cotyledon orbiculata. Poisonous. Rare in the sourveld, fairly common in the scrub round Burnshill and Fort Cox.

Cymbopogon marginatus. The distribution is discussed on page 155. This grass was formerly included under a closely-allied species which is cultivated in the East for the production of citronella oil (Stapf, 1906).

Cynanchum sp. Probably poisonous. Occasional in woodland types 2, 4 and 5. Not recorded from 3, but likely to be present.

Cyperaceae. Various of the larger species are used by the Natives in the making of baskets and mats. Common on river banks.

Cyphia assimilis. Although not recorded as an edible species in the *Flora Capensis*, the tuber is nevertheless edible. It is very watery and rather tasteless. Occasional among grass in the sweetveld.

Datura stramonium. There is at present a demand for the seeds in Europe at 17s. a pound. It is not known if the demand is temporary or not. It is a common weed in cultivated lands.

Dovyalis tristis. The fruits may be eaten, and make a good jelly (Sim, 1907, p. 130). I am unable to distinguish between this species and *Dovyalis zeyheri*, which appears to be essentially similar except for its possession of spines, and which is occasional in woodland types 2 to 5. Spininess is an unreliable key character in most members of the family.

Equisetum ramosissimum. Poisonous. On stream banks, uncommon.

Euphorbia triangularis. The strong and light wood has potential uses, and the possibilities of exploiting this species are at present being investigated by an Italian firm. Widespread in patches below the forests.

Festuca costata. Recognised as a very good thatching grass. In the Fort Beaufort district a rondavel thatched with it was demolished after 30 years. The grass was still in perfect condition. Thatching grass at present fetches £8 a thousand bundles 4 inches by 5 feet. Festuca occurs abundantly but in patches near the tops of the mountains (see photograph 76).

Ficus sp. The bark is used for rope. Woodland types 5 and 6, uncommon.

Gramineae. Several species may contain dangerous amounts of hydrocyanic acid when wilted. Cynodon in particular has been known to cause heavy losses in the Fort Beaufort district.

Hyparrhenia buchananii. Makes a brown paper of good strength and quality, and, with bleaching, a fairly good cream-coloured or white paper (Stent, 1924, p. 251). It is much used for thatch. The distribution is given on page 154.

Matricaria nigellaefolia. Poisonous. Occasional in the mud at the edges of ponds and sluggish streams.

Melianthus major. Poisonous. Occasional in wet places on forest margins.

Nasturtium officinale. Used as a salad. Fairly common in shallow running water in the sweetveld, and recorded also from the highlands.

Olea africana. One of the commonest trees in the heavy dolerite soils, being particularly plentiful in the neighbourhood of the Boma Pass. While its fruits are of no economic value, the tree is of importance for two reasons. In the first place it may be an indicator of suitable conditions for the European olive, which is closely related, and in form and foliage hardly to be distinguished from it. In the second, the wild species may be used as a stock for the cultivated one, as has been successfully demonstrated by Italian prisoners of war on several farms in the Union. There is an article by MacOwan (1897) on olive culture at the Cape. It contains useful information, and the following is a brief summary of the important points in it: Olives cannot be planted and left to fend for themselves, but require a certain amount of care and cultivation. The minimum spacing is 20 feet. The seed needs special treatment before it will germinate, and it germinates erractically and gives rise to a proportion of off-type trees. For these reasons, cuttings or truncheons give the best results. The trees come into bearing about the seventh year. The fruit is picked by hand and the oil may be extracted by a simple home-made apparatus. Hendler (1949, p. 93) states that there is also a factory at Paarl which undertakes the processing of the fruits, and that the demand for oil and pickled olives is practically unlimited.

Ornithogalum thyrsoides. The flowers sell well overseas. Some idea of the prices is given by advertisements in the Press, in which South African firms undertake to deliver the flowers in Britain at 10/6 for 50, 15/- for 100 and 27/6 for 200. The distribution of Ornothogalum is given on page 106.

Pappea capensis. The fruits are used for jelly, and also, according to Sim (1907, p. 171) for vinegar, oil and an alcoholic drink. Common in types 2 and 3.

Paspalum scrobiculatum. The grain is used as a staple article of food by the poorer people in all parts of India, but some varieties are poisonous and have been known to cause serious illness (Ayyar and Narayanaswamy, 1949). Scattered throughout the sourveld at Keiskammahoek, especially in disturbed areas near the transition to sweetveld.

Psalliota spp. Edible. Occasional in the sweetveld after rain.

Pterocelastrus tricuspidatus. A glue made from the roots is used in fitting wooden handles to iron implements (Liebenberg ms.). Woodland types 4, 5 and 6, fairly common.

Ricinus communis. The seeds contain about 32 per cent of an oil which is used in the manufacture of soap and paint. The producer could expect about 2/- a bushel for the capsules. A naturalised weed along roads and river banks and on old lands.

Rubus spp. The fruits may be eaten raw or made into jam. Common in parts of the sourveld.

Sansevieria grandis. Yields a good fibre and has been imported into Cuba for cultivation. The variety *zuluensis* occurs naturally in type 5, but is not common. It would be easy to grow, for according to a note in *Kew Bulletin* (1893, p. 187) "Small pieces of the leaf of any Sansevieria will strike root and form plants".

Sansevieria thyrsiflora. Produces a fibre of fine quality for string and thread (Leighton, 1917a, 1917b), and may be worth cultivating. As one of the requirements for the manufacture of paper and string is a plentiful supply of good water, there are possibilities for a factory at Keiskammahoek, where these conditions are amply fulfilled. One was established many years ago in Grahamstown to extract fibre from this plant, but was not a success (Brown, 1915, p. 250). It is fairly common in woodland types 2 to 4.

Sarcostemma viminale. Sometimes eaten as a salad by the Natives. Common in woodland types 2 and 3, occasional in type 4.

Senecio retrorsus. A poisonous species which is becoming a serious pest in the district, particularly where the grazing is uncontrolled and heavy. It is commonest in the transition zone between the sweetveld and the sourveld, but extends also into the two veld types themselves. Other species of Senecio may be found in quantity in almost all the grasslands. They should be regarded as potential stock poisons until they have been proved harmless.

Solanum sodomaeum. Poisonous, but not mentioned by Steyn. Dr. Adelaar of Onderstepoort reported in a personal letter that 400 gm. (about 14 oz.)of the green fruit given to a sheep caused acute hoven and death in a few hours. A smaller dose of 180 gm. (about 6 oz.) had no effect. The ripe fruits are much less toxic, and the leaves are probably harmless. This plant has almost certainly been responsible for losses among calves in the Alexandria district. It has a patchy distribution in disturbed places, mainly in the sweetveld.

Sutera atropurpurea. An infusion of the dried flowers, about a teaspoonful to a gallon of water, makes a fast yellow dye. Occasional in stony ground near Fort Cox and Burnshill.

FEATURES OF BOTANICAL AND BIOLOGICAL INTEREST

A few new records for the area were established, although the collection of the Keiskammahoek flora is still very incomplete; and some unusual plants, communities and habitats also deserve special mention.

Caesia eckloniana is found in patches in the Chatha ministerial grazing and on the lower slopes of the Hogsback near King's Nek, where it is fairly frequent. It has not previously been recorded east of Van Staadens, but Schonland (1927, p. 11) suspected that it grew in the district, and Miss L. L. Britten informs me that she has collected it near Grahamstown.

Catha edulis. There are about a dozen bushes on the outskirts of a forest patch (type 4) north of Gwili-gwili. No others have been found at Keiskammahoek.

Cliffortia eriocephalina occurs in isolated patches up to a quarter of an acre in size along the tops of the Amatole mountains. It has been seen also in the Kaga Berg 8 miles north of Bedford. Weimarck (1934, p. 45) gives the Uniondale district as its eastermost limit.

Cynodon dactylon. There is an unexplained relation between Acacia and Cynodon. It is not noticeable in the sweetveld, in which *Cynodon* spp. are now almost everywhere, but may be seen near the lower limits of the sourveld. It is that Acacia grows much more frequently in odd patches of Cynodon than in the normal sourveld sward surrounding them. As discarded grinding stones and traces of old huts show that the Cynodon patches mark disturbed areas, there are no grounds for assuming that the Acacia has by its presence killed the more advanced grasses; it appears rather that the Cynodon was there before the Acacia and presented more favourable conditions for it. Several such communities may be seen near Dontsa, and they have been noticed in the Albany district as well. Weeds also grow more readily and sometimes exclusively in these Cynodon patches. *Cynodon dactylon* forms a particularly dense mat, and has a root system which is both spreading and deep (Murray and Glover, 1935). It would not appear to offer less competition to invaders than the sourveld species, but it evidently does.

It should be noted that Meredith (1947, p. 171) reports that *Cynodon dactylon* is aggressive enough to keep out weeds, but that this is when it is well fertilised.

Debe Hollows. Below about 2500 feet, sourveld areas at Keiskammahoek are pitted with the curious hollows from which the Debe Flats have obtained their name, the Xhosa word being *indebe*, a cup or ladle. In the sweetveld they are not found, nor in the sourveld above about 2500 feet, and they are confined to a strip between the Amatole mountains and the sea, bounded roughly by Debe Nek, Evelyn Valley, Amalinda and the Nahoon River (Pickford, 1926). They are between three and four feet deep, irregular in shape and in area from one to about ten square yards, as shown in photographs 31 and 83, but near the limits of their distribution they are shallower and may sometimes be unnoticed except early and late in the day, when the sun is low enough to cast shadows across them. Examples like this occur near Dontsa. They are found in the forests as well, at least in the Debe Nek area, but the dense vegetation and the deep litter make them difficult to see. They are apparently unique in the Union, but I have seen similar hollows in the same type of veld in Kenya on the road between Nairobi and Eldoret.

Except where an intercommunicating series on a slope ensures good drainage, the sourveld grasses are absent from the bottoms of the hollows, the vegetation consisting instead of a mixture in which some of the following are usually represented:—

Alchemilla sp.	*Cyperaceae*
Andropogon appendiculatus	*Eragrostis plana*
Agrostis lachnantha	*Sporobolus indicus*
Aponogeton spathaceus	*Trifolium* sp.

There is also an ephemeral society of frogs and water-insects after rain.

Pickford has produced evidence that the giant earthworms (Microchaetus), which are abundant on the Debe Flats, are responsible for the formation of the hollows, for they tend to throw their castings in groups away from puddles and near solid objects like stones and the stems of trees, thus gradually working the earth into mounds. These earthworms are found also in parts where they do not make hollows. Pickford is of the opinion that the deciding influence in the formation of hollows is the level "hard pan" of ironstone gravel which underlies them and confines the earthworms to the superficial layer of soil.

The hollows have a marked influence on the soil moisture because of the way they hold water after rain (see photograph 31). It is interesting to note that it has been considered worth while in some parts of Canada to produce similar hollows artificially by means of a special implement known as a basin lister. The land so treated is allowed to lie idle every second year with a little cultivation to keep down weeds. Crops sown between these periods of rest thus have, in addition to the season's rain, an extra supply of water collected in the hollows the season before, and stored in the soil. By this method wheat is successfully grown without irrigation where there is a 12-inch rainfall. However, the parts in question have a winter rainfall, which coincides with the growing wheat crop, and temperatures are low and evaporation probably less than in South Africa.

Ordinary methods of cultivation soon produce an even surface in place of the former inequalities, so that the advantage of this most effective water storage system is lost, and a consequent detrimental effect on underground water supplies may logically be expected.

Dovyalis zeyheri. This bush sometimes has a subtle but nevertheless most offensive smell of carrion emanating from the leaves. The exact nature of the smell is puzzling, for it does not become stronger if one bruises the leaves, nor do they contaminate one's fingers. Sometimes the smell is absent. It is not known whether this is because of strain differences or whether it is seasonal.

Elytroppapus rhinocerotis is recorded from Kaffraria by Sim (1894, p. 47) but since it is still a rarity after 57 years, one may conclude that the environment is unsuited to it and that it is unlikely to become a nuisance in these parts. It is grazed in times of great scarcity. Only two specimens have been found at Keiskammahoek, one near Charybdis and the other on the mountains between Chatha and Dontsa Forest Stations.

Erythrina humeana. One bush is at present growing on the western foothills of Charybdis. The nearest other so far found is at Mnxesha.

Euryops spathaceus forms an isolated small community on the rocky hill overlooking the village from the east. As other species of the genus have become a pest in the Queenstown and Graaff-Reinet districts, it would be advisable to watch for any spread of these plants.

Fallow Lands. West of the golf course is a piece of level ground appearing at first sight to be rather heavily grazed virgin veld. From the neighbouring hills, however, which give a bird's-eye view of the land as a whole, and from the aerial photographs, old cultivation marks are clearly visible, and a careful inspection shows that the ploughing of former times gave rise to slight parallel ridges which have persisted to the present day. They are between 24 and 30 feet apart, and raised only a few inches above the general level of the fallow. The rise is perceptible for about 6 feet on either side of the centre line of the ridges. Among the grasses on them are more *Cynodon* and *Eragrostis* spp. than on the fallow as a whole, where Themeda predominates, and for this reason the ridges are fairly easily discernible. What makes them stand out more than their vegetation is the striking way in which the termitaria are concentrated along them. The figures, given in Table 36, indicate that in addition to being more numerous, the termitaria are also bigger on the ridges.

Dr. W. G. H. Coaton, of the Division of Entomology, has kindly given me two possibilities for this state of affairs. His letter reads as follows:—

"The *Trinervitermes* spp. favour the better drained slopes as nesting sites rather than the flats. This can be seen very strikingly in the Koffiefontein area. In the second place, the swarming winged female imagos, when settling, always seek out a somewhat elevated surface to call the males to them. In a featureless locality, especially where there is no grass and bush cover to give elevation to the females, any raised mound, hump or ridge would naturally be used by the female in preference to flat soil surface. Once male and female meet, they dealate and dig into the soil in the immediate vicinity."

Hemitelia capensis. A few specimens grow in the Wolf Ridge forests. So far, no others have been seen. Outside the district they occur at Evelyn Valley.

TABLE 36

POSITION OF TERMITARIA ON FALLOWS

Ridges	*No. of Termitaria*	*Av. Ht. of Termitaria*	*Level Strips*	*No. of Termitaria*	*Av. Ht. of Termitaria*
1	43	1·13 ft.	1	42	1·00 ft.
2	52	1·02 ft.	2	27	0·83 ft.
3	58	1·15 ft.	3	40	1·08 ft.
4	47	1·00 ft.	4	29	0·70 ft.
5	61	0·96 ft.	5	32	1·00 ft.
	261			170	

Total area of ridges 6000 sq. yds.—termitaria per acre 210·5
Total area of level strips 12900 sq. yds.—termitaria per acre 63·8

Hyparrhenia buchananii. It has been mentioned on page 110 that this grass is characteristic not of the sweetveld or the sourveld but of the transition zone between them. It also shows a preference for the margins of roads, as may be seen between Keiskammahoek and Chatha Forest Station, and near Dontsa. This peculiarity is shown on a vast scale in Griqualand East and Natal, where there is often a dense and vigorous growth of the closely-allied *Hyparrhenia hirta* along the roads, and it appears to have its counterpart in other countries as well, for in Schimper's *Plant Geography* (1903, p. 597) there is a photograph of natural prairie near Lincoln, Nebraska, showing "in the foreground cart-tracks with Andropogon—their constant attendant". It is significant that Hyparrhenia was formerly included in the genus Andropogon.

Within the limits of its normal distribution, Hyparrhenia is a common pioneer where roads and tracks are abandoned, and in fact any denuded or scoured areas seem to present specially favourable conditions for its growth. Many examples from Keiskammahoek show this, and it is a matter of common knowledge in the Transvaal and Natal. It is therefore not surprising that Hyparrhenia is apt to be plentiful where there is heavy and uncontrolled grazing. This is apparent on the damaged hillside south of the Rabula bridge on the road between Keiskammahoek and Debe Nek, and is another relation which holds true over very large areas, for the dominance of Hyparrhenia in the Tall Grass Veld (see page 110) is likewise bound up with disturbance. Mr. Acocks has informed me that protected areas in this veld are under a mixture approximating in composition the Highland Sourveld, with only a small proportion of Hyparrhenia. When the other grasses are weakened by heavy grazing, the Hyparrhenia becomes in time completely dominant, remaining so as long as its competitors are suppressed.

It grows well on fallow lands and on rocky ridges in the Transvaal, and Mr. Acocks, in a personal letter, states that it will grow in areas with an annual rainfall of as little as 6 inches, but in such places always on rocky hills, where temperatures are more favourable and soil water more plentiful than in the area generally (see pages 36 and 104). Rose-Innes (1937) reports also that near Johannesburg it grows luxuriantly round water-holes and stream banks.

All these facts lead one to the conclusion that Hyparrhenia demands a good supply of soil water. Where streams and water-holes are concerned the wetter soil is obvious. It is less so in the other examples quoted, but the arguments in favour of their having a wetter soil have been discussed on pages 28, 32 and 104, and thus do not need to be repeated. There is support for this conclusion from America as well, for Clements (1934, p. 57) looks upon the Andropogons as post-climax to the low prairie, and (pages 42–3) mentions relict patches of them on sandhills—physiologically moist, as has been pointed out on page 105 of this paper. In private letters to me, Mr. R. Rose-Innes also has emphasised the importance of the Andropogons in North America along rivers, in moist valleys, in sand and on rocky hills.

The tribe to which Hyparrhenia belongs (*Andropogoneae*) is as a whole almost confined to the tropical and warm temperate regions (Hutchinson, 1934, p. 299), being particularly well represented, in species and numbers, in what Bews calls the High Grass Savannah, described (on pages 293–5) as "a broad belt surrounding the rain forest". He reports similar High Grass Savannah with Andropogons from Ceylon. Thus, according to Bews's description also, the Andropogons may be expected to be characteristic of fairly moist habitats. Yet in his work of 1929 (page 250) Bews states that Hyparrhenia is one of the most important genera in drier types of grassland, as well as in the moister High Grass Savannah. The explanation for its frequency both in wet and dry habitats may be that the dry habitats become moist enough to support it when competition from other grasses is eliminated, and accordingly the Andropogons in areas generally dry may be expected to grow well on landslides, in selectively grazed veld, on old roads and the like, and this is in fact what does happen. The abundance of Hyparrhenia along the Natal roadsides is probably due in some measure to the loose bare earth, the run-off from the roads, and the drainage ditches, which singly or in combination cause a localised increase in soil water. It is difficult, however, to account for the dominance of this grass on road margins even along the tops of cuttings. Either there are additional forces at work, or else the rain may seep horizontally inwards by capillarity from the exposed face of the cutting.

The points put forward may reconcile two conflicting statements by Bews (1916, p. 146)—one that the Andropogons are intermediate between Themeda grasslands and bush, and the other that Andropogons, on ground freshly laid bare, are ousted by Themeda. The explanation appears to be that they are ousted by Themeda *in dry areas*, where, being out of their true habitat, they can live only if the competition is slight.

A difficulty in the theory that Hyparrhenia is one of the more mesophytic grasses is that Bews (1916, p. 146) reports that *Aristida* spp. are found together with Hyparrhenia in denuded ground, and according to him (1929, p. 211) "all species of Aristida are xerophytic". It is suggested tentatively that the distribution of *Aristida junciformis* in the Natal mist belt (Acocks, in press) may invalidate Bews's use of the word *all*.

In the cooler areas, *Cymbopogon marginatus*, which also used to be included under Andropogon, often plays the same part as the Hyparrhenia below it. It grows in the moist areas round the forest margins and may become dominant almost to the exclusion of other grasses if the original mixed cover is damaged by uncontrolled grazing. Its dependence on adequate soil water is shown in many parts of the sourveld by its local dominance where boulders shed the rain on the surrounding ground, and along dongas and old roads.

The evidence as a whole seems to be that *Hyparrhenia buchananii*, *Hypar-*

rhenia hirta and *Cymbopogon marginatus* may have high water requirements, and that this may apply as well to numbers of their allies.

Although it is mentioned in the introduction, it is perhaps advisable to stress again that these observations are true in general rather than in detail. As Mr. Acocks has pointed out to me, one may find Andropogons and their allies in areas of low and high rainfall, from sea level to the mountain tops, in frosty, frost-free, sandy, stony or turfy habitats, and a consideration of the water-relations alone in naturally incomplete. Hyparrhenia, for example, has preferences also in the matter of soils and temperatures. It seems to favour the dolerite soils at Keiskammahoek, and the lower temperatures of the highlands may be the factor preventing its growth above the forests. Hartley (1950) has with good reason concluded that temperature is the most important factor influencing the distribution of the tribe.

Olinia spp. are recorded from Stutterheim and Albany, but as far as is known have not yet been found at Keiskammahoek.

Othonna amplexicaulis has been seen nowhere else but on a nearly inaccessible terrace on Geju Mountain. It was not known east of the Port Elizabeth district before.

Stiburus alopecuroides grows in some of the vleis of the Wolf Ridge plateau. It was not previously known to extend further south than Tembuland.

SUMMARY, CHECK-LIST, GLOSSARY AND REFERENCES

SUMMARY

The district forms the drainage basin of the Keiskamma River, the encircling mountains ranging in altitude from more than 6000 feet in the north to about 3000 in the south.

The main geological formations are dolerite and the Beaufort Series, which cover roughly 25 and 75 per cent of the area and give rise to clay and loam soils respectively.

Throughout the district, 70 per cent of the rain falls during the summer.

In general, there is a drop in the average temperature from the lowlands to the highlands. The difference is roughly 12°F.

Maximum temperatures are higher in the lowlands by about 15°F.

Minimum temperatures are higher in the lowlands by about 7°F.

The diurnal range of temperature increases from the highlands to the lowlands. It averages about 17 and 26°F respectively.

There is a great deal of evidence in support of the view that areas under thick Acacia scrub were once open grassland, and that thicket formation is hastened by the elimination of grass competition.

Acacia is unlikely to become a pest in the sourveld, or where the annual rainfall is below 15 inches. It does not normally grow where the absolute minimum temperature for July averages 20°F or less, nor, in the Border area, above an altitude of about 3500 feet.

A large tree in a normal season will produce about 20,000 seeds. They are dispersed by strong winds and (to an unknown extent) by cattle. Germination under laboratory conditions is usually about 90 per cent, but may be delayed for three and a half years at least, even when the seeds are kept continually moist. They will germinate even when green and soft, provided only that they are fully formed, and if they are kept dry they may remain viable for 57 years at least. The reason for the delay appears to lie only in the impervious seed coat.

About 24 per cent of the seed is infested with weevil and wasps, and in the field—unless the seeds are covered with earth—other insects, field-mice and dry spells combine to keep the germination of the remaining 76 per cent down to a little over 1 per cent. If the seeds are covered with earth, between 6 and 7 per cent germination may be expected. Of all seedlings, about 95 per cent will usually die. These figures indicate that over 2500 seeds may be produced for every seedling that becomes established.

Natural enemies have not in the past been able to do more than check temporarily the spread of the trees.

Fire will cause a sudden abundance of seedlings, but will lower rather than increase the final germination figures.

It has been confirmed that Acacia does not regenerate if cut through sufficiently low down.

It is difficult to kill the seedlings by burning after they have become about 14 inches high.

The mixed scrub or bush which occurs in areas with an annual rainfall of about 25 inches and below also tends to increase more rapidly with uncontrolled grazing. It produces little usable timber.

The forests require a rainfall of over 25 inches. As they have fewer thorny species than the drier woodland types, little regeneration takes place if they are heavily stocked, and their tendency is to disappear unless they are protected.

Acacia is the most important pioneer tree in the succession near the lower limits of the forest. Above the limit of Acacia, *Rapanea melanophloeos* is the commonest of many.

Trichocladus ellipticus is the commonest tree in the moister forests, making up nearly half of the total.

Macchia is found near the forests, where the rainfall is about 30 inches or over. Below 4000 feet it consists almost entirely of *Cliffortia linearifolia*. This species germinates freely in the field if the light is adequate to its needs, and appears to be a successional stage more advanced than the grassland, leading to forest. As it is eaten more from necessity than by preference, it invades the grasslands slowly if they are protected or heavily grazed, and more quickly if grazing is light and therefore selective. A hot fire will kill it. Regeneration after a mild fire may be from seed or coppice shoots, but not from suckers.

The macchia above 4000 feet consists mainly of *Cliffortia paucistaminea* or *Erica brownleeae* or a mixture of the two. The laboratory germination of these two species is about 40 and 23 per cent respectively. Erica produces about 24 times the amount of seed that Cliffortia produces. Seedlings of both become established in all but the deepest shade.

Cliffortia paucistaminea is eaten in times of scarcity, *Erica brownleeae* seldom even then.

The highland macchia accumulates in time a thick litter which completely covers the ground, and makes the community a very inflammable one. Although macchia is killed by a hot fire, enough seed escapes destruction to give rise to a dense new growth. *Cliffortia paucistaminea* can grow again from suckers or coppice shoots. Regeneration of *Erica brownleeae* may be from coppice shoots but not from suckers.

Grass cannot successfully compete with it and is almost absent where the bushes grow thickly. The evidence is that the highland macchia is not seral to forest or mixed bush except in sheltered places, and that it is the climax above the forests. The historical records of grass in former days, where macchia now grows, may be explained by the annual grass fires which used to take place.

Pines, wattles and gums grow easily in the macchia zone but the indigenous forest trees do not.

The grasslands are of two types—the sweetveld, palatable and nutritious in winter and occurring where the annual rainfall is about 25 inches and under, and the sourveld, of little value for grazing in the winter, and occurring where the annual rainfall is about 30 inches or more.

If woodland types 1—4 are cleared away, the sweetveld grasses will take their place. Sourveld grasses come in if types 5—7 are cleared.

Good sweetveld has a basal cover of about 8 per cent in a Themeda-dominant sward, and 14 per cent in a Digitaria-dominant one. Good sourveld averages about 11 per cent.

Counts show that the selective grazing of sweetveld at Keiskammahoek may increase the frequency of the poisonous *Ornithogalum thyrsoides* more than sixty times. Animals, however, avoid it and deaths caused by it are rare. Most mature plants produce over a thousand seeds at a time, of which the germination in the laboratory is over 90 per cent. The rate of establishment of seedlings in the field is not known.

In the sourveld, Themeda is low in the succession, the higher stages consisting of mixed communities of grasses together with many species of herbs. With increasing altitude the sourveld soils assume a peaty texture and are easily damaged by trampling and wind erosion. Bare areas in the sourveld

are often covered with mats of *Helichrysum argyrophyllum*, which has been studied by Schonland (1927) and gives excellent protection to the soil.

The physiologically dry character of the mountain climate at times is reflected by the xerophytic character of many of the plants growing there, ericoid leaves, woolliness and sunken stomata being specially common. The dominant vegetation is macchia.

In the dry and hot lowlands the xerophytic characters are mostly spininess and succulence, and the dominant vegetation is scrub.

The forests favour sheltered positions in the moist and mild climate between the two. Grass tends to occupy the exposed positions throughout.

Where it is not interfered with, there is a tendency for all the woodland to encroach upon the grassland. Where macchia is concerned, the reason appears to be the increasing rarity of grass fires, but the reason in the scrub and forest zones is as yet obscure.

The conditions of plenty reported in the district during the last century, and the mounting destruction of the vegetation in this, make it plain that the problem of population increase is fundamental to any plans for rehabilitation.

In spite of the widespread destruction of the grass cover, there appears to be little need for elaborate reclamation works in the district. The eradication of useless plants, followed by controlled grazing, will quickly restore the veld.

Bush and Helichrysum in the sourveld may be eradicated by burning. In the sweetveld the available methods of scrub clearance are expensive and tedious. In both areas, it is recommended that no attempts should be made to clear the useless vegetation before there are facilities for the strict control of the grazing.

It will not be possible to maintain a grass sward in the highlands without the occasional use of fire.

LIST OF PLANTS AND ANIMALS MENTIONED, TOGETHER WITH WELL-KNOWN COMMON NAMES

PLANTS

Abutilon sonneratianum (Cav.) Sweet	
Acacia caffra Willd.	Katdoring
Acacia decurrens Willd.	Green Wattle
Acacia giraffae Burch.	Kameeldoring
Acacia hirtella E. Mey.	
Acacia inconflagrabilis Gerstner	
Acacia karroo Hayne	Mimosa
Acacia natalitia E. Mey.	
Acacia melanoxylon R. Br.	Blackwood
Acacia mollissima Willd.	Black Wattle
Acanthosicyos horrida Welw.	Naras
Acokanthera venenata (Thb.) G. Don	Bushman's Poison
Agrostis barbuligera Stapf	
Agrostis bergiana Trin.	
Agrostis lachnantha Nees	
Allophylus decipiens (Arn.) Radlk.	
Alloteropsis semialata Hitch.	
Aloe arborescens Mill.	
Aloe ferox Mill.	
Alternanthera repens Steud.	
Amanita muscaria (L.) Pers.	
Amaranthus paniculatis L.	Cockscomb
Andrachne ovalis Müll. Arg.	
Angraecum mystacidii Reichb. f.	
Andropogon appendiculatus Nees	
Anthospermum aethiopicum L.	
Anthospermum lanceolatum Thb.	
Anthoxanthum ecklonii Stapf	
Apodytes dimidiata E. Mey.	White Pear
Aponogeton spathaceum Hook. f.	
Argyrolobium speciosum E. & Z.	
Aristida bipartita Trin. & Rupr.	Steekgras
Aristida galpinii Stapf	
Aristida junciformis Trin. & Rupr.	
Aristea schizolaena Harv.	
Arrowsmithia styphelioides DC.	
Artemisia afra Jacq.	Wormwood
Asclepias fruticosa L.	Tontelbos
Asclepias physocarpa Schltr.	Tontelbos
Asparagus virgatus Bak.	
Asplenium bipinnatum (Forsk.) C. Chr.	
Aster bakerianus Burtt-Davy	
Aster filifolius Vent.	Draaibossie
Aster muricatus Less.	
Athanasia punctata (DC.) Harv.	
Athrixia phylicoides DC.	
Atriplex semibaccata R. Br.	Creeping Saltbush
Azima tetracantha Lam.	Naaibos

Barleria obtusa Nees	
Behnia reticulata Didrichs	
Berkheya decurrens (Thb.) Hutch. & Burtt-Davy	
Berkheya setifera DC.	
Bobartia gracilis Bak.	
Boophone disticha (L.f.) Herb.	Sore-eye Flower
Boscia albitrunca Gilg & Benedict	Witgatboom
Brachiaria serrata (Thb.) Stapf	
Brachylaena elliptica Less.	Bitterblaar
Brachypodium flexum Nees	
Bromus firmior Stapf	
Bromus speciosus Nees	
Bryum argenteum L.	
Buchenroedera multiflora E. & Z.	
Buddleja auriculata Benth.	
Buddleja dysophylla (Benth.) Phil.	
Buddleja salicifolia Jacq.	Bastard Olive
Buddleja salvifolia Lam.	Sagewood
Bulbine asphodeloides (L.) Roem. & Schultes	
Burchellia bubalina (L.f.) Sims	Wild Pomegranate
Caesia eckloniana Roem. & Schultes	
Calodendrum capense Thb.	Wild Chesnut
Calpurnia sylvatica E. Mey.	
Canthium ciliatum Sond.	Skaapdrolletjies
Canthium mundtianum Cham. & Schl.	Klip Els
Canthium obovatum Kl.	Kwar
Canthium ventosum (L.) Sp. Moore	Skaapdrolletjies
Capparis citrifolia Lam.	
Capparis rudatisii Gilg & Benedict	
Carex petitiana A. Rich.	
Carissa bispinosa (L.) Desf.	Num-num
Carissa haematocarpa DC.	
Cassine aethiopica Thb.	
Cassine crocea (Thb.) O.K.	Saffronwood
Cassine kraussiana Bernh.	
Cassine papillosa (Hochst.) O.K.	
Cassine sphaerophylla (E. & Z.) O.K.	
Cassine tetragona (Thb.) Loesen.	
Cassinopsis ilicifolia (Hochst.) O.K.	
Catha edulis Forsk.	Bushman's Tea
Celtis kraussiana Bernh.	White Stinkwood
Centella glabrata L.	
Ceratiosicyos ecklonii Nees	
Chaetacanthus setiger (Pers.) Lindl.	
Chaetacme aristata Planch.	
Cheilanthes hirta Sw.	
Chloris virgata Sw.	
Choristylis rhamnoides Harv.	
Chrysocoma tenuifolia Berg.	Bitter Karroo
Cineraria deltoidea Sond.	
Cineraria lyrata DC.	
Cissampelos torulosa E. Mey.	
Cissus cirrhosa Pers.	
Clausena inaequalis Benth.	Perdepis
Clematis brachiata Thb.	Traveller's Joy
Cliffortia eriocephalina Cham.	

Cliffortia linearifolia E. & Z.	
Cliffortia paucistaminea H. Weim.	
Cliffortia serpyllifolia Cham. & Schl.	
Cluytia affinis Sond.	
Cluytia katherinae Pax	
Cluytia pulchella L.	
Coccinia quinqueloba (Thb.) Cogn.	
Combretum salicifolium E. Mey.	Bush Willow
Commiphora caryaefolia Oliv.	Corkwood
Cotula hispida Harv.	
Cotyledon orbiculata L.	
Crabbea nana Nees	
Crassula muscosa L.	
Croton rivularis E. Mey.	
Cryptocarya woodii Engl.	
Cunonia capensis L.	Rooi Els
Curtisea faginea Ait.	Assegai
Cussonia paniculata E. & Z.	Klippersol
Cussonia spicata Thb.	Kippersol
Cycnium racemosum Benth.	
Cymbopogon marginatus (Steud.) Stapf	Lemon Grass
Cymbopogon plurinodis Stapf	Turpentine Grass
Cynodon dactylon (L.) Pers.	Kweek
Cyperus teneriffae Poir.	
Cyphia assimilis Sond.	Baru
Danthonia curva Nees	
Danthonia disticha Nees	Koperdraad
Datura stramonium L.	Stinkblaar
Desmodium scalpe (Comm.) DC.	
Diascia rigescens E. Mey.	
Diclis reptans Benth.	
Digitaria diagonalis Stapf	Finger Grass
Digitaria eriantha Steud.	Finger Grass
Dioscorea sylvatica Eckl.	
Dobrowskya scabra DC.	
Dovyalis lucida Sim	
Dovyalis tristis Sim	Wild Apricot
Dovyalis zeyheri Warb.	Wild Apricot
Dracaena hookeriana K. Koch	
Ehretia rigida (Thb.) Druce	Stamperwood
Ekebergia capensis Sparm.	Dog Plum
Elyonurus argenteus Nees	Suurpol
Elytropappus rhinocerotis (L.f.) Less.	Rhenosterbos
Embelia ruminata (E. Mey.) Mez	
Encephalartos altensteinii Lehm.	Kaffir Bread
Englerodaphne pilosa Burtt-Davy	
Entada natalenis Benth.	
Equisetum ramosissimum Desf.	
Eragrostis caesia Stapf	
Eragrostis capensis Trin.	
Eragrostis chalcantha Trin.	
Eragrostis plana Nees	
Erica alopecurus Harv.	
Erica brownleeae Bolus	
Erica caffrorum Bolus	
Erica calycina L.	

Erica floribunda Lodd.	
Erica rupicola Kl.	
Erythrina humeana Spreng.	Kaffirboom
Euclea undulata Thb.	Gwarri
Eugenia zeyheri Harv.	
Eulalia villosa (Thb.) Stapf	
Euphorbia bothae Lotsy & Godd.	Noors
Euphorbia epicyparissias E. Mey.	
Euphorbia kraussiana Bernh.	
Euphorbia obesa Hook. f.	
Euphorbia pentagona Haw.	
Euphorbia tetragona Haw.	Naboom
Euphorbia valida N.E. Br.	
Euryopus dyeri Hutch.	
Euryops spathaceus DC.	
Eustachys paspaloides (Vahl) Lanza & Matti	
Fagara capensis Thb.	Knobwood
Fagara davyi Verdoorn	Knobwood
Falkia repens L. f.	
Festuca caprina Nees var. *irrasa* Stapf	
Festuca costata Nees	
Festuca scabra Vahl	
Ficus capensis Thb.	Wild Fig
Ficus burtt-davyi Hutch.	Wild Fig
Galopina circaeoides Thb.	
Gamolepis chrysanthemoides DC.	
Gardenia neuberia E. & Z.	
Gardenia rothmannia L. f.	Candlewood
Gardenia thunbergia L. f.	
Gelonium africanum Müll. Arg.	
Geranium ornithopodum E. & Z.	
Gnidia rattrayi Moss	
Gnidia sericea L.	
Gomphrena globosa L.	
Grewia occidentalis L.	Four-corner
Gunnera perpensa L.	
Gymnosporia acuminata (L.) Szysz.	Sybas
Gymnosporia buxifolia (L.) Szysz.	Pendoring
Gymnosporia capitata Sim	
Gymnosporia deflexa Sprague	
Gymnosporia nemorosa (E. & Z.) Szysz.	
Gymnosporia peduncularis (Sond.) L. Bol.	
Gymnosporia polyacantha Szysz.	
Gymnosporia undata Szysz.	
Halleria lucida L.	Wild Fuchsia
Haplocarpha scaposa Harv.	
Harpechloa falx (L. f.) O. K.	
Harpephyllum caffrum Bernh.	Kaffir Plum
Hebenstreitia dentata L.	
Heeria mucronata Bernh.	
Helichrysum argyrophyllum DC.	Amatola Weed
Helichrysum fulgidum Willd.	Everlasting
Helichrysum nudifolium (L.) Less.	
Helichrysum petiolatum (L.) DC.	
Helichrysum rosum (Berg.) Less.	
Helichrysum splendidum (Thb.) Less.	

Helichrysum trilineatum DC.	
Helinus integrifolius (Lam.) O. K.	
Hemitelia capensis (L. f.) Klf.	Tree Fern
Heteromorpha arborescens Cham. & Schl.	
Heteropogon contortus (L.) Beauv.	
Hippobromus pauciflorus (L.) Radlk.	
Hydrocotyle asiatica (L.) Urb.	
Hyophila zeyheri (Hope) Jaeg.	
Hyparrhenia buchananii Stapf	
Hyparrhenia hirta (L.) Stapf	
Hypochoeris radicata L.	
Hypolepis sparsisora (Schrad.) Kuhn	
Hypoxis argentea Harv.	
Ilex mitis (L.) Radlk.	Water Tree
Indigofera hedyantha E. & Z.	
Jasminum angulare Vahl	Jasmine
Jasminum multipartitum Hochst.	Jasmine
Juncus lomatophyllus Spreng.	
Kiggelaria africana L.	Wild Peach
Koeleria cristata Pers.	
Lachnopylis floribunda (Benth.) C.A. Sm.	Vlier
Lasiocorys capensis Benth.	
Leonotis leonurus (L.) R. Br.	Wild Dagga
Lepidostephium denticulatum Oliv.	
Leucosidea sericea E. & Z.	
Leyssera gnaphaloides L.	
Lightfootia huttoni Sond.	
Lithops lesliei N.E. Br.	
Lobelia erinus L.	
Lycium oxycladum Miers	
Lycopodium clavatum L.	
Maerua racemulosa Gilg & Benedict	
Mariscus capensis (Steud.) Schrad.	
Matricaria nigellaefolia DC.	
Melianthus major L.	
Melothria punctata (Thb.) Cogn.	
Metalasia muricata (L.) Less.	
Microchloa caffra Nees	
Mimusops obovata Sond.	Red Milkwood
Miscanthidium capense (Nees) Stapf	Tambookie
Mohria caffrorum Desv.	
Muraltia macroceras DC.	
Myrsine africana L.	
Nasturtium officinale R. Br.	Water-cress
Nemesia melissaefolia Benth.	
Nerine alta Barker	
Nidorella auriculata DC.	
Nymania capensis (Thb.) Lindb.	Klapper
Ochna arborea Burch.	Cape Plane
Ochna atropurpurea DC.	
Ocotea bullata E. Mey.	Stinkwood
Oldenlandia amatymbica (Hochst.) O. K.	
Olea africana Mill.	Olive
Olea capensis L.	
Olea laurifolia Lam.	Black Ironwood
Oplismenus hirtellus (L.) Roem. & Schultes	

Ornithogalum lacteum Jacq.	Chinkeringchee
Ornithogalum subulatum Bak.	
Ornithogalum thyrsoides Jacq.	Chinkeringchee
Osyridicarpos natalensis DC.	
Osyris compressa DC.	Bergbas
Othonna amplexicaulis Thb.	
Panicum deustum Thb.	
Panicum ecklonii Nees	
Panicum maximum Jacq.	Buffalo Grass
Panicum perlaxum Stapf	
Pappea capensis E. & Z.	
Parkinsonia microphylla Torr.	
Passerina filiformis L.	
Passerina montana Thoday	Pakaan
Passerina vulgaris Thoday	
Pavetta capensis (Houtt.) Brem.	
Pavetta lanceolata Eckl.	Christmas Tree
Pelargonium reniforme Curt.	
Pellaea hastata (Thb.) Prantl	
Pellaea viridis (Forsk.) Prantl	
Pennisetum macrourum Trin.	
Pentaschistis juncifolia Stapf	
Peperomia reflexa (L. f.) Dietr.	
Peucedanum capense (Thb.) Sond.	
Phylica galpinii Pillans	
Phyllanthus verrucosus Thb.	
Pinus montana Mill.	
Pinus ponderosa Doug.	
Pinus sylvestris L.	
Pittosporum viridiflorum Sims	
Plectranthus calycinus Benth.	
Plectranthus fruticosus L'Her.	
Plectranthus krookii Gürke	
Plectranthus thunbergii Benth.	
Pleurostylia capensis Oliv.	
Plumbago capensis Thb.	
Poa binata Nees	
Podocarpus falcatus (Thb.) R. Br.	Bastard Yellow-wood
Podocarpus latifolius (Thb.) R. Br.	Real Yellow-wood
Polygala confusa MacOwan	
Polygala myrtifolia L.	
Polypodium polypodioides (L.) Hitch.	
Polyporus gilvus (Schw.) Fr.	
Polystachya ottoniana Reich. f.	
Polystichum adiantiforme (Forst.) J. Sm.	
Polystictus sanguineus (L.) Fr.	
Portulacaria afra Jacq.	Spekboom
Protea lacticolor Salisb.	Suikerbos
Protea macrophylla R. Br.	Suikerbos
Protea multibracteata Phil.	Suikerbos
Protorhus longifolia Engl.	
Psoralea pinnata L.	
Psychotria capensis (Eckl.) Vatke	
Ptaeroxylon obliquum (Thb.) Radlk.	Sneezewood
Pteridium aquilinum (L.) Kuhn	Bracken
Pterocelastrus tricuspidatus (Lam.) Sond.	Cherry-wood

Putterlickia pyracantha (L.) Endl.	
Pygeum africanum Hook. f.	Red Stinkwood
Randia rudis E. Mey.	
Rapanea melanophloeos (L.) Mez	Boekenhout
Relhania trinervis Thb.	
Rhamnus prinoides L'Her.	Blinkblaar
Rhigozum obovatum Burch.	
Rhoicissus capensis (Burm. f.) Planch.	Wild Grape
Rhoicissus cuneifolia E. & Z.	
Rhoicissus cymbifoliolus Sm. & Shaw	
Rhoicissus digitata (L. f.) Gilg & Brandt	
Rhoicissus rhomboidea (E. Mey.) Planch.	
Rhus dentata Thb.	
Rhus incisa L. f.	
Rhus legati Schonl.	Red Currant
Rhus longispina E. & Z.	
Rhus pyroides Burch.	Suurbessie
Rhus refracta E. & Z.	
Rhus undulata Jacq.	
Ricinus communis L.	Castor Oil
Royena cordata E. Mey.	
Royena hirsuta L.	
Royena lucida L.	Swartbas
Royena simii O. K.	
Royena villosa L.	
Rubus affinis Weihe & Nees	Bramble
Rubus pinnatus Willd.	Bramble
Rubus rigidus Sm.	Bramble
Rumex sagittatus Thb.	
Salix capensis Thb.	River Willow
Sansevieria grandis Hook. f.	
Sansevieria thyrsiflora Thb.	
Sanicula europaea L.	
Sarcostemma viminale (L.) R. Br.	
Scabiosa tysonii L. Bol.	
Schoenoxiphium sparteum (Wahl.) Kuek.	
Schotia latifolia Jacq.	Boerboon
Schotia speciosa Jacq.	Boerboon
Scolopia flanaganii Sim	
Scolopia mundii (Arn.) Warb.	Red Pear
Scolopia zeyheri (Arn.) Szysz.	Thorn Pear
Scutia myrtina (Burm.) Kurz	Droog-my-keel
Secamone alpini Schultes	
Secamone frutescens Decne.	
Selaginella kraussiana A. Br.	
Selago corymbosa L.	
Selago galpinii Schltr.	
Senecio angulatus L. f.	
Senecio brachypodus DC.	
Senecio deltoideus Less.	
Senecio juniperinus L.	
Senecio macroglossus DC.	
Senecio paucifolius DC.	
Senecio pyramidatus DC.	
Senecio retrorsus DC.	
Senecio tamoides DC.	

Setaria flabellata Stapf	
Setaria neglecta de Wit	
Setaria sphacelata Stapf & Hubb.	
Sida triloba Cav.	
Sideroxylon inerme L.	White Milkwood
Solanum sodomaeum Dunal	Bitter Apple
Sporobolus capensis Kunth	
Sporobolus centrifugus (Trin.) Nees	
Sporobolus fimbriatus (Trin.) Nees	
Sporobolus indicus R. Br.	
Stereum lobatum (Kuntze) Fr.	
Stiburus alopecuroides Stapf	
Stipa dregeana Steud.	
Stoebe cinerea Thb.	Bobo-bos
Stoebe plumosa Thb.	
Stoebe vulgaris Levyns	
Streptocarpus rexii Lindl.	
Strophanthus speciosus Reber	
Sutera atropurpurea (Benth.) Hiern	
Syncolostemon densiflorus E. Mey.	
Teclea natalensis Engl.	
Tecomaria capensis (Thb.) Spach	Tecoma
Themeda triandra Forsk.	Rooigras
Trachypogon capensis Trin.	
Tragus koelerioides Aschers.	
Trichocladus ellipticus E. & Z.	Onderbos
Trimeria rotundifolia (Hochst.) Gilg	
Trimeria trinervis Harv.	
Tristachya hispida (Thb.) K. Schum.	
Tritonia lineata Ker	
Ursinia apiculata DC.	
Venidium arctotoides (L. f.) Less.	
Vepris lanceolata G. Don	White Ironwood
Virgilia capensis Lam.	Keurboom
Wahlenbergia rivularis Diels	
Xanthium spinosum L.	
Xymalos monospora Baill.	Lemonwood
Zaluzianskya capensis Walp.	
Zantedeschia aethiopica (L.) Spreng.	Arum Lily
Zinnia multiflora L.	
Zizyphus mucronata Willd.	Wag-'n-bietjie

ANIMALS

Bruchus rufulus Fahr.	Weevil
Chrysococcyx cupreus van Som	Emerald Cuckoo
Clamator serratus Sparr.	Black-creasted Cuckoo
Columba arquatrix Temm.	Bushdove
Lamprocolius nitens phoenicopterus Sw.	Cape Glossy Starling
Lanius collaris L.	Butcher Bird
Lycaon pictus Temm.	Wild Dog
Motacilla clara Shpe.	Gray-backed Wagtail
Nariscus cinctiventris Stal	
Poicephalus robustus Gm.	Cape Parrot
Prosopophora prosopidis var. *mimosae* Maskell	Thorn Tree Scale
Turacus corythaix Wagl.	Loerie
Upupa africana Bechst.	Hoopoe

GLOSSARY

Alternes	Different dominants in patches in the same locality.
Association	A climax community with two or more dominants.
Climax	The community in which an area ultimately terminates.
Consociation	A climax community with a single dominant.
Coppice	Growth from stumps.
Disclimax	A climax caused by man or domestic animals.
Ecotone	The transition zone between two communities.
Formation	A climax community.
Holard	The total water content of the soil.
Mesic	Pertaining to conditions of medium water supply.
Mesocline	A moist cool slope.
Mesophytic	Avoiding both extreme moisture and drought.
Postclimax	A more advanced stage than the climax, existing because of localised favourable conditions.
Preclimax	The vegetation preceding the climax.
Relict	A species or community belonging to a former vegetation type.
Sclerophyll	With small hard leaves.
Seral	Successional.
Sere	A stage in the succession.
Subclimax	A community simulating the climax because further development is inhibited by some disturbance.
Sucker	Shoot of subterranean origin.
Transect	A cross section of vegetation.
Woodland	Areas whose vegetation is composed essentially of woody plants.
Xeric	Pertaining to conditions of scanty water supply.
Xerocline	A hot dry slope.
Xerophilous	Requiring dry conditions.
Xerophytes	Plants of dry habitats, which are able to decrease the transpiration rate to a minimum when under water deficiency.
Xerophytic	Referring to xerophytes.

REFERENCES

ACOCKS, J. P. H. (In Press) *Veld types of South Africa.* Govt. Printer, Pretoria.

ADAMSON, R. S. (1929) The vegetation of the south-western region. *The Botanical Features of the South-western Cape Province.* The Speciality Press of South Africa Ltd.

AINSLIE, W. (1899) *Sixty-six years' residence in South Africa.* Fort Beaufort Printing and Publishing Co.

AITKEN, D. R. (1922) The effect of slope exposure on climate and vegetation of a hill near Maritzburg. *S. A. J. Sci.* Vol. 19.

ALBANY MUSEUM. (1931) *A guide to the vertebrate fauna of the eastern Cape Province.* Published by the Trustees.

AMM, S. E. (1894) Mimosa thorn nuisance. *Agric. J. C. G. H.* Vol. 7.

ANTI-MIMOSA. (1896) Mimosa pest. *Agric. J. C. G. H.* Vol. 9.

AYYAR, K. V. S. AND NARAYANASWAMY, K. (1949) *Varagu* poisoning. *Nature.* Vol. 163, No. 4154.

BAKER, F. S. (1944) Mountain climates of the western United States. *Ecol. Mono.* Vol. 14, No. 2.

BAKER, J. G. (1926) *The Leguminosae of tropical Africa.* Erasmus Press, Ghent.

BALCHIN, W. G. V. AND PYE, N. (1950) Observations on local temperature variations and plant responses. *J. Ecol.* Vol. 38, No. 2.

BARROW, G. (1806) *Travels in the interior of southern Africa.* Cadell and Davies, London.

BAYER, A. W. (1933) The relationship of vegetation to soil erosion in the Natal thornveld. *S. A. J. Sci.* Vol. 30.

BEADLE, N. C. W. (1940) Soil temperatures during forest fires and their effect on the survival of vegetation. *J. Ecol.* Vol. 28, No. 1.
(1951) The misuse of climate as an indicator of vegetation and soils. *Ecol.* Vol. 32, No. 2.

BEARD, J. S. (1944) Climax vegetation in tropical America. *Ecol.* Vol. 25, No. 2.

BELYEA, H. C. Wind and exposure as limiting factors in the establishment of forest plantations. *Ecol.* Vol. 6, No. 3.

BEWS, J. W. (1916) An account of the chief types of vegetation in South Africa with notes on the plant succession. *J. Ecol.* Vol. 4, Nos. 3 and 4.
(1917a) The plant succession in the thornveld. *S. A. J. Sci.*
(1917b) The plant ecology of the Drakensberg range. *Ann. Natal Mus.* Vol. 3, Part 3.
(1920) The plant ecology of the coast belt of Natal. *Ann. Natal Mus.* Vol. 4, No. 2.
(1921) Some aspects of botany in South Africa and plant ecology in Natal. *S. A. J. Sci.* Vol. 18.
(1925) *Plant forms and their evolution in South Africa.* Longmans Green and Co. London.
(1927) Studies in the ecological evolution of the angiosperms. *New Phytologist Reprint No.* 16. Wheldon and Wesley Ltd. London.
(1929) *The world's grasses.* Longmans Green and Co. London.
(1931) The ecological viewpoint. *S. A. J. Sci.* Vol. 28.

BOSAZZA, V. L. (1950) The rôle of humus in soil protection. *Frmrs. Wkly.* 6/9/50.

BRAIN, C. K. (1929) *Insect pests and their control in South Africa.* Nas. Pers. Cape Town.

BRAUN-BLANQUET, J. (1932) *Plant sociology.* McGraw-Hill Book Co. New York.

BROWN, D. M. (1941) Vegetation of Roan Mountain: a phytosociological and successional study. *Ecol. Mono.* Vol. 2, No. 1.

BROWN, N. E. (1915) Sansevieria. A monograph of all the known species. *Kew Bult.*

BURTON, A. W. (1950) Local history. *Man and his environment.* Buffalo Catchment Association, East London.

BURTT, B. L. (1938) Meerburgh's *Impatiens capensis. Kew Bult.*

BURTT-DAVY, J. (1922) The distribution and origin of Salix in South Afiica. *J. Ecol.* Vol. 10, No. 1.

BURTT-DAVY, J. AND HOYLE, A. C. (1936) *Check list of forest trees and shrubs of the British Empire. No.* 2. *Nyasaland Protectorate.* Imperial Forestry Institute, Oxford.
(1940) *Check list of forest trees and shrubs of the British Empire. No.* 5. *Tanganyika.* Imperial Forestry Institute, Oxford.

CANNON, W. A. (1914) Specialization in vegetation and environment in California. *The Plant World.* Vol. 17, No. 8.

CARPENTER, J. R. (1938) *An ecological glossary.* Kegan Paul, Trench, Trubner and Co. Ltd., London.

CLEMENTS, F. E. (1905) *Research* [illegible] Publishing Co., Lincoln.
(1916) *Plant succession.* Carnegie Institute of Washington.
(1929) Experimental methods in adaption and morphology. *J. Ecol.* Vol. 17, No. 2.
(1934) The relict method in dynamic ecology. *J. Ecol.* Vol. 22, No. 1.
(1935) Experimental ecology in the public service. *Ecol.* Vol. 16, No. 3.
(1936) Nature and structure of the climax. *J. Ecol.* Vol. 24, No. 1.
COHEN, C. (1935) *Stoebe* sp. A contribution to its ecology. *J. S. A. Bot.* Vol. 1, Part 4.
(1940) *Stoebe vulgaris.* A study of an ecological problem. *J. S. A. Bot.* Vol. 6, Part 2.
COLLINS, W. F. AND WILD, H. (1950) *Poisonous plants of the Marandellas district.* Govt. Printer, Salisbury.
COOK, L. (1939) A contribution to our information on grass burning. *S. A. J. Sci.* Vol. 36.
CORY, G. E. (1920) Grahamstown. *A souvenir in commemoration of the centenary of the 1820 settlers of Albany.* East London Daily Dispatch.
COTTAM, W. P. AND EVANS, F. R. (1945) A comparative study of grassed and ungrassed canyons of the Wasatch range, Utah. *Ecol.* Vol. 26, No. 2.
COX, F. C. (1933) Alpine plant succession on James Peak, Colorado. *Ecol. Mono.* Vol. 3, No. 3.
CURSON, H. H. (C. 1926) *Some little-known South African poisonous plants and their effects on stock.* Paper read at 7th Ann. Sci. Meeting of the S.A. Vet. Med. Assoc. Pretoria. Published by the Association.
DANSEREAU, P. (1951) Description and recording of vegetation upon a structural basis. *Ecol.* Vol. 32, No. 2.
DORRIEN-SMITH, A. A. (1908) Notes (without title) on the sub-antarctic islands. *Kew Bult.*
D.W.G.S. (1949) Kalahari sand to clothe the Karroo. *Fmrs. Wkly.* 19/1/49.
DYER, R. A. (Mss.) Notes on *Acacia karroo.* Botanical Survey, Grahamstown.
(1929) Veld experiments on the Amatola mountains. *Dept. Agric. First Trienn. Conf., Report of Proc.* Govt. Printer, Pretoria.
(1930) The control of mimosa trees and scrub bush. *Farming in South Africa.* Vol. 4, March 1930.
(1931) Eradication of Acacia scrub or thorn bush. *Farming in South Africa.* Vol. 5, Feb. 1931.
(1932) Control of *Selago corymbosa. Farming in South Africa.* Vol. 6, March 1932.
(1935) The seed germination of certain species of Euphorbia. *S. A. J. Sci.* Vol. 32.
(1937) The vegetation of the divisions of Albany and Bathurst. *Mem. Bot. Surv. S. Afri.* No. 17.
EAMES, A. J. AND MACDANIELS, L. H. (1925) *Introduction to plant anatomy.* McGraw-Hill Book Co., New York and London.
E.W. (1896) Thorn tree scale. *Agric. J.C.G.H.* Vol. 9.
EWART, A. J. (1908) *The longevity of seeds.* Proc. Roy. Soc. Victoria. (Quoted by Guppy).
FENTON, E. W. (1934) Grassland retrogression in Devonshire permanent pastures. *J. Ecol.* Vol. 22, No. 1.
FLORA CAPENSIS. Reeve and Co., London.
FOURCADE, H. G. (1942) Some notes on the effects of incidence of rain on the distribution of rainfall over the surface of unlevel ground. *Trans. Roy. Soc. S. Afri.* Vol. 29, Part 3.
GALPIN, E. E. (1926) Botanical survey of the Springbok Flats, Transvaal. *Mem. Bot. Surv. S. Afri.* No. 12.
GERSTNER, J. (1948) Three closely-related Acacias of southern Africa. *J. S. A. Bot.* Vol. 14, Part 1.
GILBERT, L. C. (1949) Letter to *Fmrs. Wkly.* 23/11/49.
GILL, L. (1945) *A first guide to South African birds.* Maskew Miller, Cape Town.
GLEASON, N. A. (1912) Relation of the prairie and forest in Central Illinois. *Bot. Gaz.* Vol. 53.
GLUCKMANN, E. (Ms.) Notes on *Themeda triandra.* Botany Dept., University of the Witwatersrand.
GOLA, G. (1905) *Ricerche sulla biologia e sulla fisiologia de semi a tegumento impermeabile.* Royal Academy of Sciences, Turin. (Quoted by Guppy).
GREATHEAD, H. H. (1894) Mimosa thorn. *Agri. J.C.G.H.* Vol. 7.
GRIGGS, R. F. (1936) The vegetation of the Katmai district. *Ecol.* Vol. 17, No. 3.
(1938) Timberlines in the northern Rocky Mountains. *Ecol.* Vol. 19, No. 4.
GUPPY, H. B. (1912) *Studies in seeds and fruits.* Williams and Norgate, London.
HABERLANDT, G. (1928) *Physiological plant anatomy.* Macmillan and Co. Ltd., London.

HALL, H. (1856) Map of the eastern frontier of the Cape Colony. Edward Stanford, London.
HANN, J. (1903) *Handbook of climatology.* Translated by D. C. Ward. New York. (Quoted by J. Phillips).
HANSON, H. C. (1950) Vegetation and soil profiles in some solifluction and mound areas in Alaska. *Ecol.* Vol. 31, No. 4.
HARTLEY, W. (1950) The global distribution of tribes of the Gramineae in relation to historical and environmental factors. *Austr. J. Agri. Res.* Vol. 1, No. 4.
HENKEL, J. S. (1932) The wattle bagworm. An ecological study. *S.A.J. Sci.* Vol. 29.
(1934) *The woody plants of Natal and Zululand.* Robinson and Co. Ltd., Durban.
(1947) Humus as it occurs naturally in various African plant associations. *The Farmer.* 3/4/47.
HENKEL, J. S., BAYER, A. W. AND COUTTS, J. R. H. (1938) Subsurface erosion on a Natal midlands farm. *S.A.J.Sci.* Vol. 35.
HENDLER, M. (1949) Olive oil in the Boland. *Fmrs. Wkly.* 26/1/49.
HENRICI, M. (1926) Growth of veld plants under arid conditions of Bechuanaland. *S.A.J.Sci.* Vol. 23.
HERMENAU, K. (1949) Thornbush camps for better grazing. *Fmrs. Wkly.* 11/9/49.
HESSE, A. J. (1938) Some adaptive responses of insect life in semi-arid conditions in South Africa. *S.A.J.Sci.* Vol. 35.
HEWITT, J. (1920) Notes on the Eastern Province in pre-settler times. *Souvenir in Commemoration of the Centenary of the* 1820 *Settlers of Albany.* East London Daily Dispatch.
HITCHCOCK, H. S. (1929) The relation of grasses to man. *S.A.J.Sci.* Vol. 26.
HOBSON, S. (1896a) Deterioration of the veld. *Agri.J.C.G.H.* Vol. 9.
(1896b) The mimosa. *Agric. J.C.G.H.* Vol. 9.
HOUGHTON, D. H. (In Press) *An economic survey of the Keiskammahoek district.* Nat. Counc. Soc. Res., Pretoria.
HOWARD, A. (1925) The effect of grass on trees. *Proc. Roy. Soc.* Series B. Vol. 97.
(1940) *An agricultural testament.* Oxford University Press.
HUTCHINS, D. E. (1887) *Forests and tree planting in the eastern districts.* Paper read at Queen's Jubilee Exhibition, Grahamstown. Ms. Botanical Survey, Grahamstown.
(1892) Age of old mimosa tree in parliament house grounds. *Agri. J.C.G.H.* Vol. 5.
HUTCHINSON, J. (1934) *The families of flowering plants.* Macmillan and Co. Ltd., London.
IRRIGATION DEPT. (1939) *Rainfall map of the Union of South Africa.* Govt. Printer, Pretoria.
IRVINE, L. O. F. (1941) *The major veld types of the northern Transvaal and their grazing management.* Ms. Quinquennial report of the Towoomba pasture Research station.
JEANS, J. (1948) *The stars in their courses.* Cambridge University Press.
JUBB, A. E. (1945) *The evolution of the magisterial district of Keiskamahoek.* Ms. Public Library, Keiskammahoek.
KENDREW, W. G. (1922) *The climates of the continents.* Clarendon Press, Oxford.
KILLICK, D. J. B. (1950) *The ecology of the Table Mountain area, Pietermaritzburg, Natal.* M.Sc. Thesis, Natal University.
KOTSOKOANE, J. (Ms.) Notes on pasture analysis on the Hogsback. Botany Dept., Witwatersrand University.
KRAMER, P. J. (1944) Soil moisture in relation to plant growth. *Bot. Rev.* Vol. 10, No. 9.
LEIGHLY, G. (1937) A note on evaporation. *Ecol.* Vol. 18, No. 2.
LEIGHTON, G. (1917a) Some suitable materials for papermaking. *S.A.J. Sci.*
(1917b) Notes on the fibre produced from some of the most useful indigenous and exotic plants in the Cape Province. *S.A.J. Sci.*
LEPPAN, H. D. (1928) *The agricultural development of arid and semi-arid regions, with special reference to South Africa.* Central News Agency.
LEVYNS, M. R. (1935) Germination in some South African seeds. *J.S.A.Bot.* Vol. 1, Part 4.
(1937) A revision of Stoebe L. *J.S.Afri.Bot.* Vol. 3, Part 1.
(1938) Some evidence bearing on the past history of the Cape flora. *Trans. Roy. Soc. S. Afri.* Vol. 26, Part 4.
LICHTENSTEIN, H. (1812) *Travels in southern Africa.* Translated from the original German by Anne Plumptre. Henry Colburn, London.
LIEBENBERG, C. D. B. (Ms.) Notes on *Passerina montana.* Botanical Survey, Albany Musem.
LOUNSBURY, C. P. (1896) Thorn tree scale. *Agri. J.C.G.H.* Vol. 13.
MACBRIDE, J. F. (1950) Natural Landscapes of the United States. *Chicago Nat. Hist. Mus. Pop. Ser. Botany,* No. 27.
MCGINNIES, W. G. AND ARNOLD, J. F. (1939) Relative water requirements of Arizona range plants. *Univ. of Arizona. Tech. Bult.* 80.
MACOWAN, P. (1886) Personalia of botanical collectors at the Cape. *Trans. S. Afri. Phil. Soc.* Vol. 4.

(1890) The gum of the mimosa. *Agri. J.C.G.H.* Vol. 3.
(1897) The olive at the Cape. *S.A. Agriculturalist's Year Book and Almanac.* Wynberg Times Steam Printing Works, Wynberg.

Marloth, R. (1901) Notes on the occurence of alpine types in the vegetation of the higher peaks of the south-western region of the Cape. *Trans. S.Afri. Phil. Soc.* Vol. 2, Part 3.
(1908) *Das Kapland.* Gustav Fischer Jena.
(1913–1925) *The flora of South Africa.* Darter Bros. and Co., Cape Town.

Maximov, N. A. (1929) *The plant in relation to water.* George Allen and Unwin, London.
(1931) Physiological significance of xeromorphic structure in plants. *J. Ecol.* Vol. 19.

Meredith, D. (1947) *Fertilizing grasses in South Africa.* Agricultural Advisory Section, African Explosives and Chemical Industries Ltd., Johannesburg.

Meteorological Office (1942) *Temperature.* Govt. Printer, Pretoria.

Meyer, B. S. and Anderson, D. B. (1940) *Plant physiology.* Chapman and Hall, London.

Michelmore, A. P. G. (1939) Observations on tropical African grasslands. *J.Ecol.* Vol. 27, No. 2.
(1947) A popular misconception regarding humidity and the need for closer liaison between meteorologists and ecologists. *J. Ecol.* Vol. 34, No. 1.

Mines, Dept. of (1946) Geological Survey. *Map 136, Grahamstown.*

Mogg, A. O. D. (1929) The flora of the Vryburg district in relation to the geology. *Compte Rendu.* Vol. 2. 15th International Geological Congress.

Muir, J. (1929) The vegetation of the Riversdale area. *Mem. Bot. Surv. S.Afri.* No. 13.

Murray, G. (In Press) *Report on the reconnaisance soil survey of Keiskammahoek district, Cape Province.* Nat. Counc. Soc. Res., Pretoria.

Murray, S. M. and Glover, P. (1935) A preliminary study of the root development of certain South African highveld grasses. *J.S.A.Bot.* Vol. 1, Part 2.

Osborn, J. B. and Osborn, E. (1931) Studies on the germination of seed of the black wattle (*Acacia mollissima*), and the green wattle (*Acacia decurrens normalis*), *S.A.J.Sci.* Vol. 28.

Pappe, L. (1862) *Silva capensis.* W. Brittain, Cape Town.

Pentz, J. A. (1938) The value of botanical survey and the mapping of vegetation as applied to farming systems in South Africa. *Mem. Bot. Surv. S. Afri.* No. 19.

Pessin, L. J. (1925) An ecological study of the Polypody fern *Polypodium polypodioides* as an epiphyte. *Ecol.* Vol. 6, No. 1.

Phillips, J. (1926) *Virgilia capensis* Lamk. A contribution to its ecology and silviculture. *S.A.J.Sci.* Vol. 23.
(1927) The rôle of the bushdove in fruit dispersal in the Knysna forests. *S.A.J.Sci.* Vol. 24.
(1928a) The principal forest types in the Knysna region. *S.A.J.Sci.* Vol. 25.
(1928b) The loerie in the Knysna forests. *S.A.J.Sci.* Vol. 25.
(1929) The influence of *Usnea* sp. upon the supporting tree. *Trans. Roy. Soc. S. Afri.* Vol. 17.
(1930) Fire: its influence on biotic communities and physical factors in South and East Africa. *S.A.J.Sci.* Vol. 27.
(1931) Forest succession and ecology in the Knysna region. *Mem. Bot. Surv. S. Afri.* No. 14.
(1934) Succession, development, the climax and the complex organism. An analysis of concepts. Part 1. *J. Ecol.* Vol. 22, No. 2.

Pickford, G. E. (1926) The Kommetjie Flats. *The Blythswood Review.* May 1926.

Pilson, C. A. and Higgs, T. (Ms.) *Geography. Climate.* Geography Dept., Rhodes University.

Pio, M. (1948) Strange story of six sheep. Reported in *Fmrs. Wkly.* 21/7/48.

Pole Evans, I. B. (1935) A vegetation map of South Africa. *Mem. Bot. Surv. S. Afri.* No. 15.
(1922) The main botanical regions of South Africa. *A guide to Botanical Survey Work.* Govt. Printer, Pretoria.

Polunin, N. (1934) The vegetation of Akpatok island. *J. Ecol.* Vol. 22, No. 2.

Potts, G. and Tidmarsh, C. E. (1937) An ecological study of a piece of karroo-like vegetation near Bloemfontein. *J.S.A.Bot.* Vol. 3, Part 2.

Potzger, J. E. (1939) Microclimate and a notable case of its influence on a ridge in central Indiana. *Ecol.* Vol. 20, No. 1.

Pringle, T. (1835) *Narrative of a residence in South Africa.* Edward Moxton, London.

Rawitscher, F. (1948) The water economy of the vegetation of the campos cerrados in southern Brazil. *J. Ecol.* Vol. 36, No. 2.

Rennie, J. V. L. (1935) On the flora of a high mountain in South-west Africa. *Trans. Roy. Soc. S. Afri.* Vol. 23, Part 3.

Reynolds, G. W. (1950) *The aloes of South Africa.* Published by the Trustees, the Aloes of South Africa Book Fund, Johannesburg.

Riley, N. E. (1950) Report on proceedings of the Royal Entomological Society of London. Vol. 15, No. 11.

Rowland, J. W. and Hector, J. M. (1932) An analysis of the grazing conditions on a Potgietersrust farm. *S.A.J.Sci.* Vol. 29.

Rose-Innes, R. (1937) *Secondary succession in the highveld area of the Transvaal.* B.Sc. (Hons.) Thesis, University of the Witwatersrand.

Russell, J. (1949) The world problem of increasing food supplies. Reported in *World Crops.* Vol. 1, No. 2.

Russell, R. S. and Wellington, P. S. (1940) Physiological and ecological studies on an arctic vegetation. The vegetation of Jan Mayen island. *J. Ecol.* Vol. 28, No. 1.

Salisbury, E. (1949) Leaf form and function. *Nature.* Vol. 163, No. 4144.

Schauder, R. (1949) Unsatisfied demand for aloe juice. *Fmrs. Wkly.* 23/11/49.

Schelpe, E. A. C. (1946) *The plant ecology of the Cathedral Peak area.* M.Sc. Thesis, Natal University.

Schimper, A. F. W. (1903) *Plant geography upon a physiological basis.* Translated by W. Fisher. Clarendon Press, Oxford.

Schonken, J. D. (1930) The state of our natural water supply. *S.A.J.Sci.* Vol. 27.

Schonland, S. (1923) The Amatola problem. *Fmrs. Wkly.* 31/10/23.
(1927) On the reclamation of ruined pasture on the Amatolas near Keiskama Hoek. *Sci. Bult. Dept. Agri. S. Afri.* No. 55.

Schulze, B. R. (1947) The climates of South Africa according to the classifications of Köppen and Thornthwaite. *S.A.Geol. Jour.*

Sclater, W. L. (1900) *The mammals of South Africa.* Vol. 1. R. H. Porter, London.

Scott, J. D. (1949) *A contribution to the study of the Drakensberg conservation area.* D.Sc. Thesis, University of the Witwatersrand.

Shreve, F. (1914) Rainfall as a determinant of soil moisture. *The Plant World.* Vol. 17, No. 1.
(1917) The establishment of desert perennials. *J. Ecol.* Vol. 5, Nos. 3 and 4.

Sim, T. R. (1894) *Sketch and check list of the flora of Kaffraria.* Published by the King William's Town Natural History Society.
(1900) Botanical observations on the forests of east Pondoland. *Agri. J.C.G.H.* Vol. 16.
(1907) *The forests and forest flora of the colony of the Cape of Good Hope.* Taylor and Henderson, Aberdeen.
(1915) *The ferns of South Africa.* Cambridge University Press.
(1926) Some effects of man's influence on the South African flora. *S.A.J.Sci.* Vol. 23.

Skaife, S. H. (1926) The bionomics of the Bruchidae. *S.A.J.Sci.* Vol. 23.

Skottsberg, C. (1945) *The Juan Fernandez and Desventuradas islands.* The Chronica Botanica Co., Waltham, Mass., U.S.A.

Smuts, J. C. (1932) Climate and man in Africa. *S.A.J.Sci.* Vol. 29.

Snowden, J. D. (1933) A study in altitudinal zonation in south Kigezi and on mounts Muhavura and Mgahinga, Uganda. *J.Ecol.* Vol. 21, No. 1.

Solereder, H. (1908) *Systematic anatomy of the dicotyledons.* Translated by Boodle and Fritsch, Clarendon Press, Oxford.

Stal, C. (1864) *Hemiptera africana.* Stockholm.

Stapf, O. (1906) The oil-grasses of India and Ceylon. *Kew Bult.*

Staples, R. R. and Hudson, W. K. (1938) *An ecological study of the mountain area of Basutoland.* Garden City Press Ltd., Letchworth, Herts., England.

Stent, S. M. (1924) South African gramineae. *Bothalia.* Vol. 1, Part 4.
(1925) Bramble eradication. *Fmrs. Wkly.* 4/2/25.

Stevenson-Hamilton, J. (1937) *South African Eden.* Casell and Co., London.

Steyn, D. G. (1934) *The toxicology of plants in southern Africa.* Central News Agency.

Story, R. (1939) Notes on two important grassland types in the Vereeniging district. *S.A.J.Sci.* Vol. 36.

Tansley, A. G. (1923) Practical plant ecology. George Allen and Unwin Ltd., London.
(1934) Editorial comment. *J.Ecol.* Vol. 22, No. 1.

Theron, J. J. (undated) Lysimeter experiments. *Sci. Bult. Dept. Agri. S. Afri.* No. 288.

Thoday, D. (1924) A revision of Passerina. *Kew Bult.*
(1933) The terminology of xerophytism. *J.Ecol.* Vol. 21, No. 1.

Thomas, A. S. (1943) The vegetation of the Karamoja district, Uganda. *J. Ecol.* Vol. 31.

Thornthwaite, C. W. (1940) Atmospheric moisture in relation to ecological problems. *Ecol.* Vol. 21, No. 1.

Tooke, W. H. (1905) Notes on the geographical distribution of the Hottentot and Bantu in South Africa. *Rec. Albany Mus.* Vol. 2, Part 5.

Van Reenen, R. J. (1923) A résumé of the drought problem in South Africa. *S.A.J.Sci.* Vol. 22, No. 1.

Van Riet Lowe, C. (1938) Early man and past climates in South Africa. *S.A.J.Sci.* Vol. 35.

Versveld, W. and Britten, G. F. (1915) Notes on the chemistry of the Naras. *S.A.J.Sci.*

Walter, H. (1927) *Einfuhring in die Allgemeine Pflanzengeographie Deutschlands.* Gustav Fischer, Jena.

Warming, E. and Vahl, M. (1909) *Oecology of plants.* Clarendon Press, Oxford.

Watt, J. M. and Breyer-Brandwijk, M. G. (1932) *The medicinal and poisonous plants of South Africa.* E. and S. Livingstone, Edinburgh.

Weaver, J. E. and Clements, F. E. (1929) *Plant ecology.* McGraw-Hill Book Co. Inc., New York.

Weimarck, H. (1934) *Monograph of the genus Cliffortia.* H. Ohlsson, Lund.

Wells, H. G., Huxley, J. and Wells, G. P. (Undated) *The science of life.* The Waverley Book Co., London.

West, O. (1951) The vegetation of Weenen county, Natal. *Mem. Bot. Surv. S. Afri.* No. 23.

White, F. J. S. (1948) *The Helichrysum weed problem on the Amatolas near Keiskamma Hoek.* B.Sc. Hons. Thesis. University of the Witwatersrand.

Whitlock, L. (1949) Reply to query in *Fmers. Wkly.* 12/10/49.

Whitmore, J. S. (1949a) Frost. *Farming in South Africa.* Vol. 24, No. 277.

(1949b) Rains fall to design of nature's architecture. *Fmrs. Wkly.* 16/2/49.

Wicht, C. L. (1949) Forestry and water supplies in South Africa. *Bult. Dept. For. S. Afri.* No. 33.

Wild, H. (1950) Evidence for the existence of ecotypes of the Msasa in Southern Rhodesia. *S.A.J.Sci.* Vol. 47, No. 4.

Willis, J. C. (1919) *A dictionary of the flowering plants and ferns.* Cambridge University Press.

Wolhuter, H. (1948) *Memories of a game ranger.* Wild life Protection Society of South Africa. Distributed by Central News Agency.

Wood, J. G. (1934) The physiology of xerophytism in Australian plants. *J. Ecol.* Vol. 22, No. 1.

Woodard, J. (1925) Factors influencing the distribution of tree vegetation in Champaign county, Illinois. *Ecol.* Vol. 6, No. 2.

Zeuner, F. E. (1949) Time in evolution. *Rep. Smithson. Instn.*

APPENDIX

PRACTICAL POINTS REGARDING THE WORKING OF METEOROLOGICAL INSTRUMENTS

The instruments were installed according to the cyclostyled instructions of the Union Division of Meteorology. In addition, the *Meteorological Observer's Handbook* was consulted, and *Notes on Meteorological Instruments and Observations* (1938). A number of difficulties not mentioned in these papers was encountered during the year's observations, and it is felt that a discussion of them may be useful to future workers.

The Stevenson screen contains two shelves, respectively for the thermograph and the hygrograph. The space for these instruments is too cramped to allow one to give them their routine weekly attention where they stand, and for this they have to be taken off the shelves. It is convenient to place them in a shady place on the ground so that every part is easily accessible, but in rainy weather this is not practicable, and they have to be brought forward to straddle the edge of the opening of the screen before they can be attended to. This is inconvenient and risky, for they rest on a narrow ledge and cannot with safety be left unsupported. It would be an improvement to the screen if it had a light wooden frame like a picture frame hinged to the bottom shelf and fastened to the upper shelf by a catch, so that the frame could be let down to support the instrument when the screen was opened. The suggested addition is shown in Figure 15.

Rainy weather was the biggest source of trouble when the instruments had to be visited. The drops drive into the screen, wet the pens, smudge the charts and get into the mechanism of the instruments. A shelter over the screen is a necessity at such times, and could best be made from the plastic material used for waterproof capes. This, being light and transparent, could be easily stored in the screen or carried, and would not obscure the light—an important consideration on a dull day. It could be secured by catches on the outside of the screen along the front edges, with corresponding metal eyes let into the material.

The construction of the fonts supplying the distilled water to the wet bulb thermometers was the cause of a good deal of wasted time. The neck of the font is so narrow that one has difficulty in pouring in the distilled water in a stream fine enough to prevent a bubble forming in the neck and blocking the entrance. It requires a steady hand under the best conditions and becomes a lengthy and tedious process on a windy day. It would be better to have the wick passing through a small hole in a metal cap screwing on to a neck with a wider opening. In addition, the fonts should be made slightly larger. There is a risk of the water's becoming exhausted in dry and windy weather.

The recording instruments were of various makes, each with its own good features and weaknesses. The points which follow should be kept in mind by any worker who is in a position to select his instrument.

Most of the drums are secured by a locking nut on the top end of the spindle. It has the standard right-hand thread, with the result that when the clockwork is set in motion the rotation tends to screw the nut more and more tightly down on the top of the drum. Until this was discovered, the instruments were continually being halted by the increased friction which was caused. The nut was thereupon discarded, but this allowed the drum to wobble when the chart was being adjusted to the correct time at the beginning of its run, and there was consequent difficulty in getting an accurate and neat time mark. The spindle should be fitted with a left-hand thread, or the drum secured by a strong clip.

The usual device for holding the chart on the drum is a metal bar. In some of the instruments it is hooked to fit over the top rim of the drum, and is flat at its lower end so that it can be thrust through a slot in the flange at the base of the drum. The metal bar and the drum are usually of equal length, which means that it is impossible to put the bar in position unless both ends engage the drum at the same instant. This is shown in Figure 16. To add to the difficulty, the bar is springy and slightly curved to ensure that the chart will be firmly gripped. More than once, when numbed fingers failed to hold the bar properly, it slipped off the drum and was flicked away by its own tension. The bar should be appreciably longer than the drum, and an improvement which is found in some of the instruments is a bar hinged to the drum at one end and with the free end provided with a catch to hold it when in position.

The disadvantage of all the bar mechanisms is that one has to take care that the chart is fitted so that the bar does not cover the position where the pen should be. This is liable to happen in the mornings, because the lines marking the early hours are close to the edge of the chart, where the bar must grip. If this does occur, one is faced with the nuisance of removing the chart, rotating it slightly and replacing it. The possibility is avoided in some instruments which have their charts with one of the edges gummed and overlapping the other, and easily detachable at the end of the period by means of suitably placed perforated lines separating it from the body of the chart. Wet weather did not cause the gum to slip. It was found to hold the chart firmly under all conditions.

Chart MET 20 for thermographs is apt to give trouble unless it is trimmed a little. The gridded portion of the chart, that is the chart not counting the space for captions, has too much overlap. The consequent difficulty is shown in Figure 17. Let us suppose that the instrument is beginning its run at 8 a.m. The pen should start its record at point A, but this point is covered by the other end of the chart no matter what the position of the chart may be with respect to the bar. It is possible to fold the outer end upwards, as shown, and place the pen beneath it, but towards the end of the week the raised flap of paper will lift the pen away from the chart when it approaches its original position. The only way of dealing with this imperfection is to tear away the free end of the chart flush with the edge of the bar.

The hygrographs have the strands of hair protected by a cover of coarse wire mesh. The cover interferes with the washing of the hair, and could be with advantage hinged so that it could be easily moved aside when necessary.

Most instruments have a motor which runs for only a little more than a week with one winding. Inevitably the operator will at some time forget to wind one of the motors, thereby ruining a set of records. A 14-day motor would make this mistake a harmless one, and a 14-day motor is quite practicable. One of the instruments had a motor which ran for over three weeks with one winding.

The drum should be removable. In one thermograph the drum was a fixture. It was an awkward task to change the charts even in fine weather, and a great deal more difficult under bad conditions.

The meshing of the drum with the motor should be perfect. One of the drums, even though not fully home on its seat, could still engage with the driving cog of the motor. This fault, a difficult one to notice, resulted in a chart with readings too low, and corrections had to be applied in consequence.

The key for winding the motor should be a fixture. One is liable to mislay loose keys and they are a nuisance to carry round from one instrument to the next.

The bar for lifting the pen off the chart should be firm and perpendicular. One had a slight outward bias, and sometimes interfered with the working of the pen when it was near the upper limit of its range. Here again it was difficult to discover where the trouble lay. It would be an advantage to have a double bar—the usual one between the pen and the drum, and another between the pen and the front of the instrument, to prevent the pen from touching the glass panel there. It is not possible to erect the screen so that it will remain entirely rigid in a strong wind, and the vibration set up during a spell of windy weather, together perhaps with blasts of air into the screen, are sometimes enough to swing the pen away from the drum so that the back of the ink reservoir comes in contact with the glass. The slightest smear of ink on the outside of the reservoir will make it stick. A makeshift aid is to rub a candle-end over the inside of the glass panel opposite the ink reservoir. The thin film of grease will prevent the trouble.

It sometimes happens that the pens are blown violently about if the charts are changed in windy weather, and a double bar would have the added advantage of protecting them from injury.

Some pens have their hinges not perpendicular to the base of the instrument but set with a slight bias, sufficient to hold the nib against the drum. The weight of the pen is often too little for the nib to make a legible mark, and a temporary solution is to tilt the whole instrument slightly back by placing a thin strip of cardboard under the front feet. It is preferable to use instruments which have pens with an adjustable pressure against the drum.

The days of the week should not be marked on the charts. Field workers with a battery of instruments cannot as a rule change the charts every seventh day because only the morning hours of the seventh day are marked on the chart. Where the instruments are numerous or far apart, the work extends into the afternoon and the instruments attended to then will be found with their pens off the end of the chart, consequently it is necessary to change the charts every sixth day, and for this reason the initial day on the charts changes with each run. The thermograph charts should in addition not have the temperatures marked up on them. Seasons may be extreme enough to send the pen off the chart unless the pen is adjusted to read high or low as the case may be. Marked charts have to be endorsed accordingly and are confusing to read. A further improvement would be to have the hours on the charts marked according to the 24-hour clock. The 12-hour system is cumbersome and out of place in formally scientific work.

For the routine handling of the instruments, the following supplies were found necessary:—

1. Charts.
2. Muslin and wicks.
3. Ink for instrument pens.
4. Keys for screen locks.
5. Distilled water.
6. Keys for clockwork motors.
7. Camel-hair brush.
8. Benzine.
9. Razor-blade.
10. Notebook.
11. Thin oil.
12. Alcohol.
13. Filter-paper.
14. Small screwdriver.

The use of items 1 to 7 is either explained in the meteorological instructions cited or is self-evident. The charts, rolled face outward, were carried in a round tin, and when withdrawn for use retained their cylindrical form, which made it easier to fit them round the drum. The old charts were dried with filter-paper and stored in a separate tin.

There was not enough ink to allow a supply to be stored in each screen, but this would have been the best arrangement because the bottles could never be kept perfectly clean and were an endless source of anxiety in the haversack which was used to transport the supplies.

The benzine was used for flushing out the working parts of the instruments when this was necessary. It was applied with a fine brush and the excess was removed with a piece of the muslin used for the wet bulb thermometer.

When working with the wet bulb thermometers, it was found to be quicker to twist the wicks than to plait them as shown in *Notes on Meteorological Instruments and Observations*. The four strands, after having been knotted at the muslin, were combined to form two sets of two. These were rolled each in the same direction, then placed side by side and rolled in the opposite direction to form the necessary cord. The muslin was cut free by means of a razor-blade when ready for changing.

When the charts were changed it was found advisable to enter the relevant details in a notebook and copy them on the chart in ink later. This gave a neater chart and helped to make the extraction of the figures easier.

To give a smooth action, thin oil was sometimes needed on the moving parts of the instruments. The merest trace, applied on the end of a grass-stalk, was all that was necessary. Any tendency for the oil to spread to other parts of the instrument could be checked by cleaning with benzine.

Alcohol was useful for cleaning spots of recording ink off the instruments, and from time to time it was needed for washing the reservoirs on the pens when they became clogged with an accumulation of old ink.

For minor adjustments and repairs a small screwdriver was carried.

The one new instrument of the set could be depended upon to work, within its mechanical limitations, perfectly from one week to the next. The others gave a great deal of trouble, and any break in the record of one instrument meant that the rest of the readings for this period had to be discarded, otherwise the records for the five stations would not have been comparable. The most serious gaps in the records were caused by break-downs in the motors and by nibs which would fail, without warning, to trace their mark on the chart. The number of breaks may be seen from Figures 1 and 2, in Chapter 1. Complete records from all five stations were obtained on only 178 days in the year. With new motors and new ink reservoirs on the pens it should be possible to get a year's records practically complete for any number of stations. A spare hygrograph and a spare thermograph should be kept, to be substituted for any instrument which may become faulty and require adjustment or repairs.

Some of the recommendations are for very small improvements. An accumulation of petty annoyances in conjunction with a number of serious difficulties, however, can and does turn a smooth routine into an exacting and difficult task, and instruments should be most carefully examined for constructional shortcomings before being put to use, specially in parts far from the main station.

The rainfall was measured according to the standard meteorological procedure. Improvements on these methods have been suggested by Fourcade (1942).

REFERENCES

FOURCADE, H. G. (1942) Some notes on the effects of incidence of rain on the distribution of rainfall over the surface of unlevel ground. *Trans. Roy. Soc. S. Afri.* Vol. 29, Part 3.

METEOROLOGICAL OBSERVER'S HANDBOOK (1942) H.M. Stationery Office, London.

NOTES ON METEOROLOGICAL INSTRUMENTS AND OBSERVATIONS (1938) Publication I.D. 278, Govt. Printer, Pretoria.