KEISKAMMAHOEK RURAL SURVEY

VOLUME I

THE NATURAL HISTORY OF THE KEISKAMMAHOEK DISTRICT

Edited by

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PIETERMARITZBURG

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KEISKAMMAHOEK RURAL SURVEY

IN FOUR VOLUMES

Volume I The Natural History of the Keiskammahoek District.

Volume II The Economy of a Native Reserve.

Volume III Social Structure.

Volume IV Land Tenure.

The National Council for Social Research initiated and financed a comprehensive Rural Survey of the Keiskammahoek District, a Native Reserve in the Ciskei. This survey, which was directed by Professor Lindsay Robb, covered a number of different aspects of which the studies in this volume form a part.

Acknowledgment is made of the financial assistance given by the National Council for Social Research both in the conduct of the Survey itself and in the publication of this Report. Opinions expressed and conclusions reached are, however, those of the authors, and are not to be regarded as being an expression of the views of the National Council for Social Research.

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INTRODUCTION

by

EDGAR D. MOUNTAIN

In 1946 the newly-formed National Council for Social Research decided to sponsor a study of the social conditions of the Keiskammahoek District as a sample Native rural area, and Professor R. L. Robb was appointed Director. He had devoted a lifetime to agricultural and pastoral research and after a period as research professor at Pretoria University saw military service as a colonel in the last war and later joined the Native Affairs Department. From the beginning it was intended to make the investigation on as wide a basis as possible with emphasis on sociology, economics, and agriculture and this volume represents the results of a study of the physical conditions or more fundamental factors upon which the socio-economic features are to some extent dependent. The bulk of the scientific work was performed voluntarily by experts and with this in mind, it is easy to understand that the survey is by no means completely comprehensive but a considerable amount of information was collected in many branches of study by paid workers.

A topographic map was prepared by plane-table under the supervision of the late Mr. A. H. Harcourt Wood, then Head of the Survey Department of Rhodes University College, but this proved insufficiently accurate and for most purposes a map enlarged from the Kingwilliamstown Divisional Map and modified by reference to air photographs was adequate. These air photographs were taken in 1939 and were not good enough for modern requirements in map-making but in 1949 a new set of photographs were taken and these were employed by the Trigonometrical Survey in the preparation of a new series of maps used for the maps illustrating these reports.

The geological survey was carried out by Dr. E. D. Mountain, Professor of Geology at Rhodes University, with assistance by Mr. A. Ruddock, Mr. G. R. Davis and students and was the first branch of the survey to make a beginning. This work involved a preliminary study of available maps and topography which provided material for the report on topography. Climatic data were extremely meagre and no serious attempt could be made to collect satisfactory information without continuing over a period of many years, so that only a general statement of the position is made by Dr. J. V. L. Rennie, Professor of Geography at Rhodes University. In the soil survey Mr. George Murray of the Division of Chemical Services, Department of Agriculture, was assisted in the field by Witwatersrand University students. A botanical survey was made by Mr. R. Story of the National Botanical Survey who is stationed in Grahamstown and he has written a special report, although a much more detailed account will appear in a Botanical Survey memoir on the subject. This volume is concluded by an account of the vegetation of the catchment areas, a topic of special interest in an area particularly liable to soil erosion, studied by Professor Robb.

Assistance was generously given in various ways by the Botanical Survey, the Division of Chemical Services, the Trigonometrical Survey and the Departments of Native Affairs (through the Native Commissioners), Irrigation, Transport, and Defence.

TOPOGRAPHY OF THE KEISKAMMAHOEK DISTRICT

by

EDGAR D. MOUNTAIN

The area investigated is the Magisterial District of Keiskammahoek and corresponds very closely with the drainage basin of the Keiskamma River above Fort Cox. It does not include the Amatole Basin.

It is situated roughly between 27° and 27° 15′ east and between 32° 33′ and 32° 48′ south, and is about 220 square miles in area. It is somewhat circular in shape with a diameter of some 16 miles and the village of Keiskammahoek at the centre. Kingwilliamstown is 20 miles, and Stutterheim 18 miles in a straight line from the village, while the nearest point on the coast is about 45 miles away.

The area forms a natural basin carved out by the headwaters of the Keiskamma River and nestles against the eastern end of the Winterberg Range, known locally as the Amatole Range, to the north. Thus the greatest heights are found to the north along a line running from the Hogsback in the north-west to Mount Thomas in the north-east, but even along the southern margin the land rises to a considerable height at Zanyokwe and only along the Keiskamma River itself near Fort Cox in the south-west corner does the mountain barrier fail to complete the ring of mountains surrounding the area.

The basin, however, within the confining ring of heights does not possess anything approaching a flat floor. Nowhere within the basin is it possible to obtain a comprehensive view of the whole area because it is completely dotted with ridges running from the boundary heights and with isolated mountains of various sizes. In fact the area possesses a high degree of dissection in striking contrast with the extensive flats immediately to the south and stretching away towards Peddie.

The river at Keiskammahoek is a little over 2,000 feet above sea-level and drops some 400 feet to Burnshill where it leaves at the lowest point of the area, while the highest point is actually the top of the third Hogsback or Belek'-umntana with its beacon at 6,360 feet sea-level situated on the boundary line of the area near the north-west corner. The massive krantz four miles to the north-east called Geju Mountain and shown on the topographical map (1 : 500,000) as Gxulu Mountain does not fall far short of this figure at its summit, being 6,030 feet sea-level, while the corner beacon half a mile or so further north is 6,125 feet sea-level. There is thus a range of altitude amounting to some 4,760 feet.

The towering heights along the northern boundary, which include the Hogsback, Geju Mountain, Cata (5,386 feet), the Doorn Mountains, and Mount Thomas (5,325 feet) and form the bulk of the Amatole Range, are really in the nature of an escarpment. That is to say that the country to the north of these heights drops relatively gradually and when one climbs out of the Keiskamma Valley to the north, one emerges into a different type of country characterised by the undulating grassy slopes of the Cathcart district. To the east and west, however, the confining heights are of a different character. In the west the Wolf Ridge runs down from the Hogsback Mountains as far as Mount McDonald (3,270 feet) and merely separates the Keiskamma River basin from the Amatole basin of roughly the same height above sea-level. In the east, running southwards from Mount Thomas but separated from it by the Dontsa Pass, is the Pirie Range including Mount Kemp (4,666 feet), Mount Charybdis (4,244 feet), and the Bailie's Grave plateau. This is virtually the eastern extremity of the Winterberg Range so that the eastern slopes drop straight down to the coastal plain at about 2,000 feet around Kingwilliamstown and there is an uninterrupted view from the eastern edge to the coast in the neighbourhood of East London. At its southern end, the Pirie Range near West Peak (4,184 feet) swings westwards past Ntabandoda (3,060 feet) shown on the topographical map as Intaba ka ndadu, and Zanyokwe (3,032 feet) where it also forms a relatively narrow ridge, dropping steeply to the coastal plain on the south but more gradually to the north into the Keiskamma River basin.

The drainage pattern within the basin follows a fairly simple dendritic system. According to the Divisional Map (1 inch equals 200 Cape roods) the source of the Keiskamma River is on Ditchling about a mile east of the Cata beacon and on entering the area the river pursues a somewhat headlong career in cascades and waterfalls

over bare rock into the Ndlovini Forest. On emerging from the forest, it appears to have several alternative names, but after acquiring the waters of the Mqukwana and Mthwaku Rivers just above St. Matthew's College property, the name of the Keiskamma River becomes firmly established. So far, the river has dropped about 2,500 feet from its source in a distance of five miles, and consequently the river and its tributaries have steep valleys in which they flow rapidly. But from here onwards the main river flows over stretches of comparative flatness which have caused it to pursue a winding course separated, however, by stretches of more rapid drop. The flatter winding portions are characterised by alluviation and the existence of a flood-plain at least on the concave side of the river and sometimes on both, while in the intervening portions the banks rise steeply from the river, and rocky outcrops are frequent in the river bed. Thus, flood-plain conditions exist more or less continuously from St. Matthew's College to below the village of Keiskammahoek and again, more poorly developed, below the Boma Pass and near Fort Cox. Between St. Matthew's College and Keiskammahoek the river is joined on its left bank by the Gwili-Gwili River rising on the steep slopes west of Mount Kemp and north of Mount Charybdis, and flowing through the Gwili-Gwili location. The winding nature of the valley just above the Boma Pass is not connected with present-day alluviation seeing that the river winds between steep hills, but is inherited from some previous cycle, so that the meanders are deeply incised.

At Keiskammahoek the Keiskamma River normally receives a considerable volume of water from a tributary on its right bank, the Gxulu River, from which is taken the supply of water for the furrows of the village. This river is formed some six river miles upstream by the confluence of the Mnyameni and Chatha Rivers, both with considerable volume. The Mnyameni drains the area between the Hogsback and Geju Mountains, while the source of the Chatha lies in a huge basin eaten out behind the east-west line of Chatha and Geju Mountains. Both rivers are fast flowing and only small patches of alluvial deposits are formed along the Gxulu River and its tributaries.

Below Boma Pass the Keiskamma River is joined, on its right bank again, by the Wolf River, the valley of which has been opened up recently for about five miles by the newly-constructed road to King's Nek and the Hogsback village. The upper five miles of the river, however, still remain somewhat inaccessible. It rises on the southern slope of the third Hogsback in a rather peculiar isolated basin and on emerging through a steep-sided valley is joined by a tributary on its right bank which drains the Wolf River Plateau, a perched, shallow basin which, just above its outlet, is often swampy. After confluence with this tributary, the valley continues steeply the whole way to the Keiskamma River and there is no possibility of appreciable alluviation.

The last tributary of any importance is the Rabula River which drains the south-east portion of the basin and thus joins the Keiskamma on its left bank. It rises on the south slopes of Mount Charybdis and after the addition of a number of tributaries carries a fair volume where it crosses the Keiskammahoek-Kingwilliamstown road. From here the river follows a meandering course, but it is still fast flowing along a confined course with no appreciable flood-plain.

The slopes of valley-floor, valley-side and ridge are not by any means uniform nor even continuous but in many places are interrupted by terraces. For example, the western slopes of the Mnyameni Valley are broken by a conspicuous shelf probably at about 4,000 feet sea level, while the Wolf Ridge and the Bombane Ridge at their lower ends are both flattened at about 3,500 feet. The great differences of altitude over short distances, such as 3,000 feet in two miles at the head of the Mnyameni River Valley, indicate the prevalence of steep slopes, but in detail such slopes vary very considerably and most of the steepest slopes are broken by rock krantzes which may be actually vertical or even overhanging. On the other hand, practically none of the area could be classed as a region of low relief or undulating, except very locally. Perhaps the flattest areas are to be found around the Bailie's Grave beacon, in the Gwili-Gwili and other locations, and possibly on part of the Wolf River plateau.

In general outline the topographical features of the basin reflect the main structural characters. A broad barrier of dolerite with a slight tilt towards the north cuts right across the drainage from the Boma Pass and the Nqhumeya Heights through Red Hill and past Tshoxa to Schwarz's Krantz, thus vaguely dividing the basin into two separate parts. Another similar barrier, but not quite so clearly defined, passes east-west through Bombane Hill, north of Keiskammahoek. It fades out to the west in the Mnyameni River Valley and

to the east it crosses the bottom of the Dontsa Pass and links up with the Pirie Range below Mount Kemp. Structurally the high ground including Ntaba-ndoda and Zanyokwe along the southern margin of the area forms yet another similar barrier.

In the north the structure is somewhat complex but is dominated by yet another gently tilted dolerite barrier swelling out locally into the magnificent krantz of Geju Mountain. The upper reaches of the Wolf River on the other hand are confined by a series of intersecting dolerite sheets diversely oriented, and further east a more steeply dipping sheet or dike from Cata beacon to Dontsa Pass occurs as a conspicuous wall of rock and isolates peculiar drainage basins behind it.

GEOLOGY OF THE KEISKAMMAHOEK DISTRICT

by

EDGAR D. MOUNTAIN

INTRODUCTION

Reliable contour maps on a scale suitable for geological mapping were not available. The topographical map of the Union (1 : 500,000 or 1 inch equals 8 miles), sheet 5, published by the Government Printer, 1936, with 500-foot contour intervals was useful as a locality map, while the later Fort Beaufort topographical map (1 : 250,000) adds a little further information. The Kingwilliamstown Divisional sheet is published in two scales. The smaller scale map is 1 inch equals 840 Cape roods (about two miles) and the larger scale is 1 inch equals 200 Cape roods. Surveyed positions are not plentiful and plots are not always tied in, while water-courses and tracks are merely sketched. A Forest Department map, unpublished and based on the larger scale Divisional map, was also available.

For a base map, the smaller scale Divisional map was enlarged photographically to a scale of 1 inch equals 1 mile; a negative was prepared and projected in an enlarging apparatus and a drawing made, which proved to be quite reasonably accurate. Details of roads and water-courses were added in the field and from aerial photographs.

Fortunately, a complete set of aerial photographs was available for field use, though these photographs are not accurately vertical. Moreover, owing to great differences of altitude they show great distortion as between different levels. The photographs were taken at 12,000 feet, while differences of height in a single photograph may, in exceptional cases, be as much as 3,000 feet. However, these photographs have been invaluable in locating position in the country where no fixed points were visible. Difficulties certainly arose in

transferring data from photograph to map. This was done by establishing a scale for each photograph by comparing with known distances on the map and then by fixing an unmapped spot by its distance from points already established on the map. Errors are introduced if points are at appreciably different heights or if check points are available only on contiguous photographs which do not accurately fit together. However, by averaging out results it seems that the greatest errors are of the order of 100 yards.

GENERAL GEOLOGY

The geological formations encountered in the area are confined to the following three groups :—

3. Alluvium.
2. Karroo Dolerite.
1. Beaufort Series.

The Beaufort Series

The rocks included in the Beaufort Series represent a conformable sequence of sedimentary rocks varying in character from mudstone to sandstone. Apart from local disturbance by dolerite intrusion, these sediments dip fairly uniformly over wide areas at angles up to about three degrees towards the north so that even in flat country there would possibly be about 1,000 feet of thickness exposed. Differences in height between the northern boundary of the area and the Keiskamma River Valley in the south must account for an additional 4,000 feet or more of thickness, so that the actual thickness of sedimentary rock occurring in the area must amount to some 5,000 feet in all probability.

When fresh, these rocks are pale bluish-grey or greenish-grey and consist generally of a fine-grained feldspathic sandstone weathering to various shades of yellow, brown and red or, more rarely, white. Apart from any alteration by dolerite intrusions, it seems as if the coarser the sediment the more resistant it is to erosion and possibly to weathering, so that the better defined shelves of sediment appear invariably to consist of coarse sandstone. The coarse sandstone moreover tends to weather into large elliptical masses often with quite conspicuous bedding-planes. Some of this coarse sandstone is probably of a quality suitable for building stone and is, for example, being used at St. Matthew's College in the building of a small chapel. The ridge behind St. Matthew's is capped with a similar sandstone, while another well-defined sandstone horizon forms a line of krantzes at the head of certain small forests on the east side of the Mnyameni River Valley.

With increasing fineness of grain, the bedding planes become less conspicuous and the rock, on weathering, tends to break up into smaller and irregular little blocks. Such material often crumbles easily when wet and tends to become muddy so that the name mudstone is commonly applied, although much of this material is in reality a fine sandstone and perhaps only a little is true mudstone. The name siltstone is sometimes used for an intermediate grade between sandstone and mudstone and it is probable that the great bulk of the finer sediments could correctly be called siltstone. The finest grade can easily be recognised by taking a small fragment and grinding it between one's teeth. True mudstone feels quite smooth and does not grit. A sample of this type, for instance, from the Schwarzwald Forest has an average grain size of 0.01 mms. and could certainly be regarded as a true mudstone. Such material is easily weathered and under ordinary circumstances highly erodible. It might be noticed that these finer-textured sediments are extraordinarily massive and show very little sign of lamination parallel to the bedding and for this reason are not to be regarded as shale. In fact, no rocks have been observed anywhere in the area which could be regarded as typical shale, though lamination is sometimes poorly developed. Mudstone and fine sandstone are suitable, and frequently used, as a road-dressing material.

An attempt was made, but without success, to discover some characteristic and persistent sandstone horizon to act as a marker. Either the sandstone bands die out laterally over fairly short distances or they are disturbed by dolerite to such an extent that they cannot be picked up again beyond the larger intrusions. In any case, none of the coarser sandstone horizons seems to be greater than 20 to 30 feet thick and they do not in consequence form really conspicuous features. It is, however, possible that detailed work would enable some of these horizons to be mapped over limited distances, but the time required would not appear to be justified for the present purposes.

These sediments are regarded as being of Lower Beaufort age, but no fossils have been found exc[illegible]identifiable

lumps of fossilised wood. These rocks, however, can be followed along the road from Breakfast Vlei to Debe Nek without any suggestion of anything other than Lower Beaufort. The base of the Lower Beaufort Series is found just south of Breakfast Vlei and the sequence is quite typical throughout that stretch of country. In the Peddie district the Lower Beaufort Series is about 10,000 feet thick, so that it is quite reasonable to suppose that the whole of the sedimentary rocks of the Keiskammahoek District are also of this age. The beds are very nearly horizontal and may, in fact, stretch as far as the vicinity of Cathcart. The sediments of the Beaufort Series in general are typically feldspathic and the sandstones are very distinct from the purer quartz sandstones of the Cape System. For this reason they generally give rise to richer soils. Even in the sandstones, feldspar accounts for over fifty per cent of the constituents, and the rock as a whole contains over three per cent of potash. It seems as if there is here no great disinction chemically and mineralogically between the sandstone and mudstone, the grain-size being the essential difference. It is often stated that Karroo soils are rich under irrigation, but it is doubtful whether the soils here can be classed as Karroo soils seeing that they have developed under a much greater rainfall than typical Karroo soils and consequently have lost, in all probability, much of their potash and phosphate. Although the nature of the original rock is important in soil formation, climate also plays an important role.

In the neighbourhood of the larger dolerite intrusions, mudstone has been converted into lydianite and sandstone to quartzite. Lydianite is a blackish compact flinty rock possessing a slight purplish tint and silky appearance. It breaks up naturally into angular blocks and weathers at the surface to a creamy-coloured coating. It sometimes contains well defined nodules about an inch across due to alterations of original calcareous concretions or other calcareous matter into epidote and other minerals and their presence may be taken as an almost certain sign of approach to dolerite. The quartzite produced from the Beaufort sandstones is grey-green, feldspathic and very tough. Near the dolerite it generally shows a high degree of jointing into columns with relatively sharp edges. While lydianite and quartzite are typically produced from fine and coarse sediments respectively, there is complete gradation between the two.

Karroo Dolerite

Dolerite covers twenty-five per cent of the total area and forms intrusions into the Lower Beaufort sediments. Broadly, these intrusions are of two types, inclined sheets and dikes. While the former crop out with an extensive surface area, the latter are highly elongated and generally appear only as lines on the map.

(a) *Inclined Sheets*

As is common in this part of the Union, the inclined sheets mostly have a small dip towards the north. It is as though they all formed part of a gigantic system of parallel sheets derived from a deep-seated source somewhere far to the north towards Basutoland. They are mostly up to 100 to 200 feet thick but the sheet forming the krantz of Geju Mountain is exceptional in swelling out locally pod-like in shape to a thickness of some 700 feet.

In the south, the relatively abrupt rise of level from Debe Nek to the top of Ntaba-ndoda, a rise of about 1,000 feet, is accounted for by the presence of the first of these sheets, which we may call the Zanyokwe sheet, near the top. Although the crest of Ntaba-ndoda is made of the overlying sediments, the krantz on the south side consists essentially of dolerite which is continued to the west as a band below the Zanyokwe beacon to Burnshill and can thence be followed eastwards as a conspicuous bluff outside the area. Its slope to the north very nearly coincides with that of the valley starting between the Zanyokwe beacon and Ntaba-ndoda so that it follows down the valley to its confluence with the Rabula River. In the neighbourhood of Burnshill there are abundant exposures along the main road from Middledrift to Keiskammahoek.

The second sheet is much nore extensive within the area and forms a wide and irregular belt through the Boma Pass and eastwards past the Inquamaya beacon. It may be called the Nqhumeya sheet after this locality. In the Boma Pass, the krantz on the west side of the road indicates the position of the sheet, although the krantz itself consists mostly of the overlying indurated sediments.

The sheet does not appear to be very thick here. Further west it turns up the Wolf River Valley where it can be followed as a krantz for some distance along the left bank. The base crosses the Wolf River and can be followed to a krantz below Mount McDonald, but the top is confused on the right bank of the Wolf River by a sheet

dipping rather steeply towards the river. To the east, in the neighbourhood of the Inquamaya beacon, krantz-like outcrops are not so common, but bright-reddish soil derived from this sheet is widespread and is conspicuous, for example, where the short road from the east end of Keiskammahoek to the Nqhumeya location rises steeply from the river. Reddish and chocolate-brown soils are furthermore widespread between here and Red Hill on the Keiskammahoek-Kingwilliamstown road as can be clearly seen from that road. It crops out on the steep slopes below Tshoxa and forms a series of disconnected outcrops to the east, terminating in the rectangular-looking block known as Schwarz's Krantz just east of Farm 334. In the vicinity of the Inquamaya beacon, this sheet dips north at about ten degrees, but further south, as is generally the case with inclined sheets, the inclination diminishes.

The third sheet occurs a little north of St. Matthew's and can be observed from the lower part of the Dontsa Pass. In the west it crosses the Mnyameni River just beyond where the road up the valley crosses the river for the second time. From there it can be followed down the river on the lower slopes of the right bank for a little over a mile where it bifurcates, the upper branch dying out somewhere below Gxulu Kop and the lower branch much earlier. East of the Mnyameni River Valley, the outcrop bends southwards along the high ground and is again displaced northwards in the Chatha River Valley where it can easily be followed from the road and is probably from 50 to 100 feet thick. On Bombane Hill it nearly reaches the beacon Keiskama Hoek 3,477 feet and follows a zigzag course through Nqolo-Nqolo and may be called the Nqolo-Nqolo sheet after this locality. This sheet is dipping at five degrees also to the north and its winding outcrop is due to a succession of valleys running southward. It eventually crosses the Dontsa Pass road before the first big bend in the road where an uneven floor is exposed.

The roof at this point where it crosses the road makes a steep rise just beyond the road, where the outcrop forms a bewildering mass of domes. From here outcrops are continuous in the form of a krantz near the foot of rising ground and run in a southerly direction. Beyond the neck leading to the Gwili-Gwili Valley, the base of the intrusion drops rather suddenly into the valley showing either that the form of the intrusion is no longer a sheet dipping north at a shallow angle or alternatively that we are now dealing with another intrusion. Moreover, dolerite can be followed from here continuously in krantzes round the head of the Gwili-Gwili Valley into Mount Charybdis where it swells out locally into a lenticular mass 200 to 300 feet thick and beyond that continuously again to Pirie Peak West.

In the extreme north of the area, there is a complex arrangement of sheets. A large mass enters the area at the corner of the Cathcart farm Mountain Top and immediately divides into two. The northern branch forms the skyline-krantz cutting across to the south-east corner of the farm Highgate. The southern branch swells out rapidly to form the magnificent krantz of Geju Mountain where the thickness is some 700 feet, but a mile or so east of the high krantz this pod-like sheet divides again. From here the more northerly branch, already thinned to 100 feet or less, is responsible for an attractive waterfall on the main stream where it closely follows the contour forming a beautiful forested amphitheatre above the Forester's house at Chatha. It turns up steeply almost dike-like at about 45 degrees across the Chatha River towards the high ground near the Cata beacon where it loses its identity amongst a number of concurrent intrusions. A mile or so beyond the Cata beacon two sheets emerge from the complex and may possibly be regarded as the continuation of this body. The more southerly of the branches from Geju Mountain represents the bulk of the large intrusion but, instead of behaving like a sheet, it plunges down with steep sides into the forest below and only then appears to flatten out into the sheet on which the Forester's house is actually situated. Across the Chatha River, it swings round the south slopes of Chatha Mountain in the Ndlovini Forest. In the upper reaches of the Keiskamma River, however, it becomes entangled in a thick dike-like body and is difficult to trace, although it seems likely that it is the same sheet as occurs ultimately just below the turn-off to the waterfall on the Dontsa Pass.

Structurally, the Wolf River basin is quite different. Sheets here are dipping at relatively steep angles up to 30 degrees or so and are not dipping towards the north. The Hogsback sheet dips roughly south, while that of the Mnyameni Ridge dips in a westerly direction and the sheet on the other side of the Wolf River dips towards the north-east. Gxulu Kop is situated on another relatively steep sheet and other similar sheets occur further south. The sheet forming a krantz around the edge of the Wolf River plateau and running into the Schwarzwald Forest is, however, more or less horizontal.

(*b*) *Dikes*

Dikes occur throughout the area varying from a few inches to some hundreds of feet thick, but no attempt was made to map the very small ones. For example, between Keiskammahoek and St. Matthew's College a number of small intrusions are encountered in the roadside too small to map, in addition to those actually shown on the map.

Probably the most conspicuous dike is that which crosses the Dontsa Pass between the two sheets. On the road it is 400 feet wide and dips south-west at about 60 degrees. It shows some excellent contacts with invaded sediment along the old road but cannot be traced much beyond the hairpin bend towards the south-east owing to thick forest. To the north-west, however, it can be followed clearly as a striking feature almost to the Cata beacon. The dip appears to vary between 40 degrees and 60 degrees always to the south-west. As its course is through the Dontsa Forest, it may be called the Dontsa dike.

Another dike-like body of some size crosses the Keiskammahoek-Kingwilliamstown road about three-quarters of a mile from the boundary. Its margins are not very clear on the road but the width of outcrop is nearly 200 yards and the dip about 60 degrees to the south. To the east it dies out within a mile or so, but to the west the width of outcrop swells out to several hundred yards where it joins the Zanyokwe sheet and it seems unlikely that it can persist as a dike with that width.

A dike comparable to the above is seen below Mount Kemp right on the boundary of the area tapering out in a south-westerly direction.

(*c*) *Structure and Texture*

A really remarkable feature of the dolerite intrusions is that the larger ones with the exception of the Zanyokwe sheet are all continuous with each other in outcrop. Although the Nqhumeya and Nqolo-Nqolo sheets are apparently parallel, dipping to the north at similar angles, yet in the high ground in the east they link up. This is due to the fact that to the south the Nqolo-Nqolo sheet flattens out and finally, beyond the plateau of the Bailie's Grave beacon, actually drops quite steeply to the level of the sheet at Schwarz's Krantz.

It should be mentioned that the mapping of dolerite is sufficiently accurate to delineate the major masses with reasonable certainty. In some cases, however, where the terrain is difficult to negotiate, further work could possibly reveal additional information. In one or two places in particular, further details would be required for a thorough interpretation which, however, was not regarded as essential for this survey.

All the larger intrusions, both sheet and dike, consist of coarse ophitic dolerite except near the margins where they are locally fine-grained, while small dikes are often porphyritic or basaltic. A few small dikes, however, have a peculiar silky appearance in the hand specimen due to a subparallel arrangement of tiny feldspar phenocrysts in a basaltic groundmass. Small veins of mobilised sandstone and mudstone are widespread in the larger intrusions which also have occasional patches of dolerite-pegmatite.

In the absence of distinctive outcrops, the smaller dolerite intrusions are generally picked up in the first instance by the colour of their soil. Subsoil is a brownish-yellow which grades under different conditions into a reddish colour, a chocolate-brown or sometimes black. This difference in colour appears to be connected with differences in topography which in turn influence the humidity of the soil. For instance, poorly drained soils appear more likely to be black. These dolerite soils, it need hardly be mentioned, are very clayey with a well-defined crumb structure, and tend to crack on drying. The subsoil (sabunga) is very suitable for road surfacing but the soil itself becomes very slippery when wet, and unmade roads on dolerite are generally impassable in wet weather.

Alluvium

Owing to the highly dissected nature of most of the terrain, river valleys are steep and narrow and do not possess flood-plains. Locally, however, where downcutting has been hindered by resistant rock-masses, some of the rivers have widened their course by meandering, and have developed flood-plains by deposition of alluvium. An attempt has been made to map the larger deposits, which are almost confined to the main water-course, the Keiskamma River. The meandering of the rivers as seen on the map is not always associated with a wide valley for, in places such as just above the Boma Pass, the river winds between steep hills because original meanders at a higher level have cut down vertically to the present level. No alluvium is found under these conditions.

It is not always easy to recognise alluvial deposits or to determine how far they extend from the river. River banks generally expose gravel, sand or silt which has at some time been brought down by the river, but exposures further from the river are generally poor. A terrace 20 feet or less above the river bed is perhaps the most reliable indication of an alluvial deposit, but the inner edge of the terrace is difficult to locate when the valley side rises only gradually. Where a terrace is not well defined and the banks rise from the river continuously, unconsolidated material found on the slope may not have been deposited by the river at all, but may be due to rainwash from above. Such material is termed colluvial in contrast to alluvial, and in the case of a well-defined terrace the inner edge shows a gradation from alluvial to colluvial material.

It is, of course, possible to distinguish between alluvial and colluvial material where it is characteristic of a rock-type which occurs up the river and not on the adjacent slopes of the valley or vice versa. For instance, some of the lands of St. Matthew's College on the right bank of the Keiskamma River contain abundant dark constituents suggestive of derivation from dolerite, although this has not been carefully examined. Now there is no dolerite on the slope immediately above these lands, whereas there is the Nqolo-Nqolo dolerite sheet athwart the river some two miles upstream, so that it seems reasonable to regard the soil of these lands as originally brought down by the river.

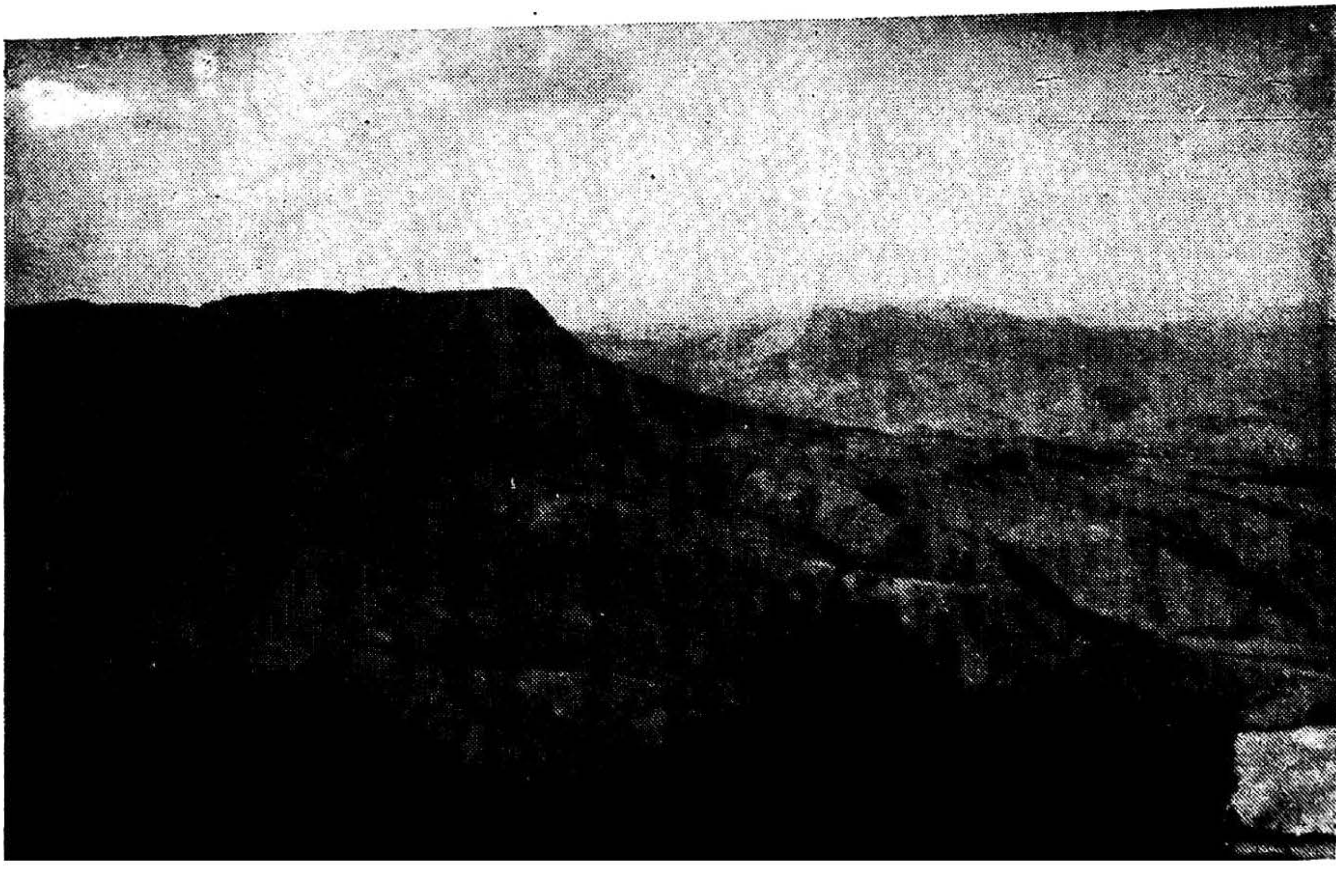
In April, 1948, rains were exceptionally heavy and at Keiskammahoek the water rose to the front of the hotel. This appears to be near the limit of alluvial deposition and consequently it is probable that all the alluvial material observed is related to the present river level. There seems to be a general opinion that high floods are becoming more and more frequent and that this is due to accelerated run-off as a result of the destruction of vegetation in the catchment areas. There are, however, insufficient data at present to support or refute this opinion.

No high-level terraces were observed.

Conclusion

Incidental reference has been made to dolerite soil in connection with the mapping of dolerite, but soil is generally regarded as a subject for specialist study and is not dealt with in any detail in a geological

Hogsback looking south-west.
Dolerite sheet underlain by Beaufort sediments with transgressive contact. Foreground consists of Beaufort sandstone. *Keiskammahoek*, 1949



Dolerite outcrop weathering into typical domes, part of the Nqhumeya sheet at its b
Keiskammahoek-Kingwilliamstown road, three and a half miles from Keiskammah
on the map. *Keiskammahoek*, 1

Alluvial deposit consisting of silt with pebble bed at base and showing horizontal surfac
of flood plain.
Gxulu River one and a half miles from Keiskammahoek. *Keiskammahoek*, 194

Transported soil.
Dolerite soil and spheroid overlying Beaufort sediment and derived by soil creep fro
higher up the slope.
Stutterheim road, five miles by map from Keiskammahoek. *Keiskammahoek*, 19

NOTE ON THE CLIMATE OF THE KEISKAMMAHOEK DISTRICT

by

J. V. L. RENNIE

The district lies within the Warm Temperate Zone, and since it receives at least a moderate rainfall, it has a humid subtropical climate like regions elsewhere that are similarly situated. It should be noted, however, that typical humid subtropical conditions are not met with in the Ciskei but along the coast further north. The district is at no great distance from the winter rainfall area which might be regarded as commencing at Algoa Bay, a fact of situation which accounts for a fair proportion of winter precipitation. In addition, the arid Karroo approaches the district in the west and indeed extends into the lower valley of the Great Fish River less than fifty miles distant; this is consistent with a mean annual rainfall of little more than twenty inches at Fort Cox on the south-west border.

The range of altitude is considerable, from 1,800 feet at Fort Cox and 2,000 feet at Keiskammahoek to 4,000 to 6,000 feet in the surrounding mountains. The escarpment is here just over 50 miles inland, and together with the southward extending spurs is sufficiently near the sea and sufficiently elevated to account for markedly increased precipitation at the higher levels, much of it derived from easterly and southerly winds. Elevation also accounts for considerable differences in temperature from place to place, and no doubt maps of the district showing this and other elements of climate would show rather complex distribution patterns in which the influence of relief would be prominent. Some of the differences appear in the records of five meteorological stations set up by Mr. R. Story for comparative readings for the period September, 1948, to August, 1949.[1]

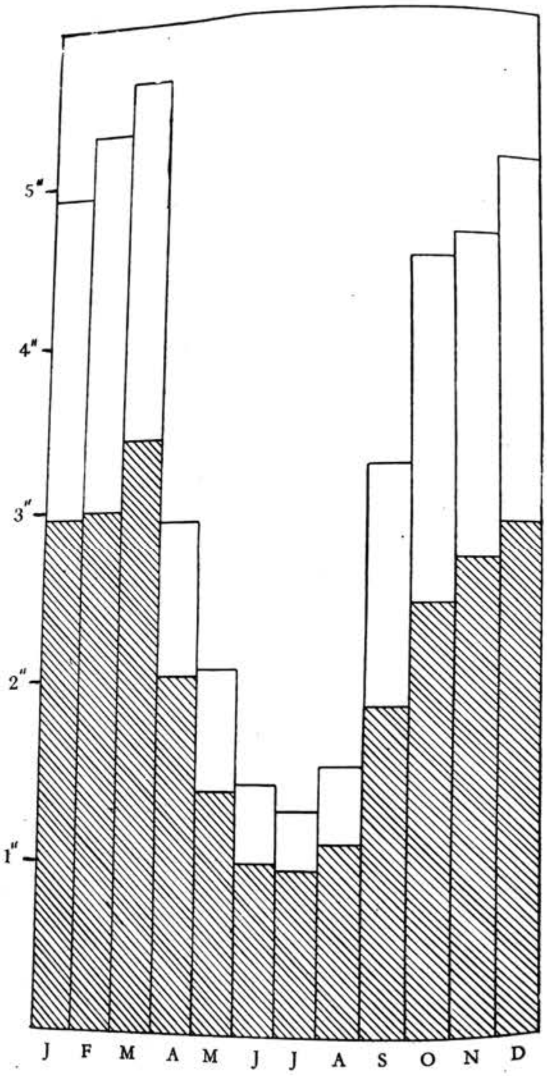
[1]See R. Story. Mem. 27, "Botanical Survey."

It was found at an early stage of the survey that the only official climatic records that were available for the district were rainfall returns for six stations, four of them in the marginal forest areas at some elevation, one at Keiskammahoek in the centre of the basin, and one at Fort Cox in the south-west corner. Of these, three have been recording for 50 years or more, including the station at Keiskammahoek, and only one for less than 25 years, that at Fort Cox. It is thus possible to obtain a fairly satisfactory general picture of the mean annual rainfall distribution in the district, and of the seasonal incidence, as well as some idea of rainfall reliability. Records from neighbouring areas have also been available, such as those of Evelyn Valley (3,500 feet) just outside the district, and Wolf Ridge (3,000 feet).

The mean annual rainfall is about 40 inches at several of the higher stations, and rises to 73 inches at Evelyn Valley[1] just outside the area. The amount drops rapidly in valley situations, being only 25 inches at Keiskammahoek. The area has appreciably more rainfall in summer than in winter, with about 70 per cent in the summer period from October to March. The wettest month is, however, at the end of the summer in March, this being preceded by a succession of wet months with at some stations a subordinate maximum in November or December. Between March and October the monthly rainfall figures drop from about three to five inches to about one inch in each of the winter months June, July and August, the annual variation being substantially the same at each station (see figure showing the mean monthly precipitation for Keiskammahoek at 2,000 feet, 25.5 inches per annum, and for Wolf Ridge at about 3,000 feet, 42.3 inches per annum, both for the period to the end of 1935).

Rainfall conditions vary greatly from year to year and mean figures convey a most inadequate picture of what is actually experienced. At Evelyn Valley the annual rainfall has on occasion during the past 60 years approached 120 inches and dropped well below 40 inches, and a similar range of variation occurs throughout the district. The wettest month is not infrequently advanced or retarded by one, two or even three months, while the percentage falling in the summer period may drop to little more than 50 per cent in some years.[2] A high degree of unreliability is accompanied by the normal occurrence of long dry spells of weather with low humidity and rapid evaporation,

[1]For 49 years up to the end of 1935 (in Rainfall Normals).
[2]See tables in Story, Mem. "Botanical Survey," No. 27.



Mean monthly rainfall for Keiskämmahoek (lower figures) and for Wolf Ridge (higher figures)

and these might be expected to be of greater significance at the lower levels where rainfall is less and temperatures higher. There is no accurate information available about evaporation in the district, but the Irrigation Department's recently published map of the Union[1] showing evaporation isopleths shows this area as falling within a belt whose evaporation from standard tanks is between 50 inches and 60 inches per annum: this is, however, based on only 57 tanks for the whole Union, none of them near the district, and doubtless the evaporation rate varies very considerably in different localities.

There are no available temperature records for the district itself, but for stations such as Lovedale and Kingwilliamstown below the mountain belt, mean monthly temperatures range from about 55 degrees Fahrenheit to about 73 degrees Fahrenheit, while at Evelyn Valley at 3,500 feet the figures become 50 degrees and 62 degrees respectively.[2] The average frost period for Lovedale is of the order of two months from the beginning of June to early August, and for Kingwilliamstown about one month. It should be obvious that the high relief of the district and the complex pattern of its contours will give rise to considerable differences in the temperature conditions from place to place and much complexity in distribution, and that differences from year to year must also occur. Observation of temperature conditions at selected localities in the district, to bring out relations to altitude and aspect, would provide valuable data for a proper understanding of the distributional aspects of settlement and production in the district, both actual and potential.

[1]Irrigation Department maps on water resources, scale 1 : 1,500,00 (1950)
[2]Met. Office, Dept. of Irrigation publication *Temperature*, 1942.

THE SOILS OF THE KEISKAMMAHOEK DISTRICT

by

G. MURRAY

1.—SOILS

According to C. R. van der Merwe's "Soil Groups and Sub-groups of South Africa," the Keiskammahoek soils belong to the Sub-group "Semi-coastal belt of the Eastern Province." Dr. van der Merwe describes them as podsolic soils derived almost exclusively from sedimentary rocks. Intrazonal soil types of lithogenic origin in this sub-group are developed from the basic igneous rocks—mainly dolerite.

During the investigation it was found that the soil types conform very closely to the geological structure. For most of the soils in Keiskammahoek 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 soils can conveniently be grouped according to the parent rock from which they originate.

(*a*) Soils Derived From Sedimentary Rocks

The soils derived from the sedimentary rocks may be sub-divided into three sub-types :—

S.1. Shallow grey loam on weathering sandstone.

S.2. Grey loam with ferruginous concretions on yellowish clay and sandstone.

S.3. Yellowish-brown sandy loam on sandstone.

The profiles are, as a rule, well-developed for they have been subjected to the prevailing climatic conditions for a considerable period of time. The varying depth depends mainly on three factors :—

(1) Variable rates of decomposition of the different sedimentary rocks.

(2) Locality.

(3) Climatic conditions.

S1.—*Shallow Grey Loam*

The surface horizon consists of grey, sandy loam to loam with a coherent almost single-grained structure. The depth of this layer varies from a few inches to a couple of feet. Immediately below this is a layer of light yellowish-brown gritty sandy clay loam containing a fair amount of loose ferruginous concretions (ouklip shot). The presence of the ouklip indicates a temporary water-logging during the rainy season. The soil mass rests either on partly decomposed sandstone or fissured sandstone. The root penetration through the soil is good and assists in disintegrating the parent rock.

This soil sub-type, due to its topography, shallowness and lack of plant nutrients is not suitable for cultivation. Crops must inevitably suffer from drought due to its low water-holding capacity. It has indeed often been ploughed in this district and is prone to sheet erosion as soon as the vegetal cover is removed.

S2.—*Grey Loam on Clay*

The A horizon is composed of grey sandy loam to loam with a crumbly structure on the surface but more cemented lower down. In Mbems location the surface soil is sandy and powdery and therefore very prone to be disturbed by the wind when under cultivation. Immediately above the impermeable B horizon a band of loose iron concretions is encountered.

The B horizon consists of densely packed clay, which impedes root penetration considerably, with scattered iron concretions embedded in the clay. The concretionary matter decreases with depth. The clay is multi-coloured being usually yellowish-grey mottled black and brown. The C horizon consists of the parent sedimentary rock in a partially decomposed state.

This sub-type is usually much deeper than the S.1 sub-type. It is prone to erode into gullies, for the clay sub-soil is very erodible and seems to melt away causing undercutting of the surface soil. Much cultivation takes place on this soil; the crops obtained are poor, due probably to lack of plant nutrients.

Type samples were taken and the analysis shows an acidic surface soil with a negligible percentage of water soluble salts. The sub-soil has a neutral reaction and an increasing percentage of soluble salts.

Nitrogen in the nitrate form is present, but is only found as a trace in the ammonia form. There is low phosphorus content in the surface soil but that element increases with depth. Potassium occurs only in traces and this soil generally is deficient in plant foods.

S.3.—*Yellowish-brown Sandy Loam on Sandstone*

The surface soil is grey sandy loam overlying a layer of yellowish-brown sandy loam. The B horizon consists of yellowish-brown fine sandy clay loam merging into clay of the same colour. There are no ouklip concretions in this horizon and the favourable structure confirms that internal drainage is good. The profile rests finally on semi-decomposed sandstone. Its colour is presumably due to the proximity of dolerite soils. The favourable structure and good depth of this soil place it in a class above the other sandstone soils. Unfortunately, not much of this soil was encountered—only a few small areas were recorded in the Gwili-Gwili location. No attempt was therefore made to indicate it on the small scale plan.

(*b*) Soils Derived From Dolerite

The soils developed from dolerite occur in three distinct sub-types :—

- D.1. Immature black clays (shallow).
- D.2. Red (chocolate) clays (deep).
- D.3. Black well-developed clays (deep).

D.1.—*Immature Black Clays (Shallow)*

This sub-type consists of black clay with a good open granular structure usually 1-2 feet deep. Scattered iron concretions are found just above the decomposing dolerite on which the profile rests. Boulders are embedded in the profile and scattered on the surface. The clay, due to its granular structure, possesses self-mulching properties, which help to retain absorbed water. This soil type is usually encountered on the higher slopes of the dolerite ridges and dikes. It

is a good medium for plant growth where depth permits, but it occurs only in isolated and inaccessible areas, and the ever-present boulders obstruct ploughing.

The analysis of a type sample shows an acidic soil with a low percentage of water-soluble salts. The nutrient elements nitrogen, phosphorus and potassium are low in the surface soil but occur in increasing quantities as the parent rock is neared.

D.2.—*Red Clays (Deep)*

The profile consists of a red clay throughout. In the virgin state the surface colour is chocolate, but cultivation seems to bring out the characteristically red colour, which is caused by the deposition of iron oxide on the soil particles.

The surface soil has a well-developed crumbly structure, but lower down the profile becomes more dense and cloddy. The soil is deep (usually six feet and more) and there is no obstruction or impervious layer until the semi-decomposed dolerite or solid rock is reached. Root penetration and aeration are good and the soil has a favourable water-taking and water-holding capacity.

This sub-type is usually found on the sunny side of the dolerite ridges where the aspect favours higher soil temperatures. It is eminently suitable for cultivation for it usually occurs on easy slopes where the drainage is good and where it is not prone to erode. By virtue of its granular structure in the virgin state it withstands the ravages of erosion much better than soil types S.1. and S.2.

Chemical analysis of type samples prove that this soil type is richer in plant nutrients than the other residual soils derived from sandstone. The elements phosphorus, potassium and calcium are present in reasonable quantities. Nitrogen, however, is scarce and that element must be stressed when fertilising this soil type.

D.3.—*Black Well-developed Clays (Deep)*

The A horizon consists of black or dark brown clay loam which contains some ferruginous concretions in its foot. The B horizon is made up of a lighter coloured closely packed clay, rather impermeable and extending for a good depth. This rests on the yellowish-brown decomposing dolerite which merges into the solid rock. There is much evidence in the profile of colluvial drift from the slopes higher up. Both this and sub-type D.2 are the more mature phases of soils derived from dolerite.

This soil is found in more level plains where the drainage is somewhat impeded. But, owing to the general steep topography there is not much of this sub-type in the Keiskammahoek District. Where it does occur, the area it covers is usually insufficiently large to indicate on the plan. Only a few main patches near Fort Cox have been shown.

The above then are the main types of residual soils found in the district. But, owing to the complexity of the geological formation, there are, in addition, many intermediate types. The sandstone for instance, occurs in many different gradations from coarse-grained sandstone to very fine mudstone and layers of each material may have different rates of decomposition. The resulting soils, although genetically and morphologically the same, may vary considerably in depth, texture and colour.

Then, too, at the point of contact of the dolerite and the sedimentary rocks, the resulting soils are necessarily of mixed origin. Moreover, due to the mountainous topography, much colluvial slide has taken place. For instance, it is not unusual to find a typical red doleritic profile (D.2) overlying weathering sandstone. Or, conversely, weathering dolerite boulders have been found in a typical grey loam profile (S1 or S2).

Thus it is practically impossible to lay down strict boundaries between soil types, even if an intensive soil survey were to be conducted.

In addition to the residual soils listed above, there is a limited amount of alluvial soil.

(*c*) Alluvial Soils.—A

Again, due to the mountainous terrain there is very little accumulation of transported material. The steep slopes end abruptly in the watercourses which convey the water away in swift running streams. Here and there, however, a valley broadens out when transported materials may be deposited.

The texture and colour of the alluvial soils depend on the locality from where the transported material originated. Most of the alluvium is old, for secondary aggregation has taken place.

The whole profile consists usually of dark-grey clay which becomes fairly dense as the depth increases. Drainage is poor. Unless the plant nutrients have been removed by cultivation, these soils should

be fertile. Type samples were taken on the St. Matthew's alluvium, but the results of the chemical analysis do not necessarily apply to all alluvial soils in the district. The St. Matthew's soils have been intensively cultivated under irrigation for several years, and the balance of plant nutrients has undoubtedly been upset, even although fertiliser and manure have been applied.

The soil reaction is slightly acid. In the sub-soil there is a fair accumulation of water-soluble salts, which fact, together with free water found there, is an indication of bad drainage. The nitrogen and potassium content is low while phosphorus is present in larger quantities. The mechanical analysis shows an increasing clay content with depth.

(*d*) Alluvial-Colluvial Soils.—A-C

Closely allied to the alluvium and hardly distinguishable from it are the so-called alluvial-colluvial soils. Like the alluvium, the texture and colour depend on which of the two residual soil types commands the locality. The influence of the sedimentary rocks imparts to the soil the typical grey colour and a lighter texture, while the doleritic influence results in a black colour and a more clayey texture. In either case, the alluvial-colluvial soils are deep, possess a favourable structure and are initially fertile.

The influence of colluvial drift is confined not only to the alluvial soils. It is also evident in the residual soils. Deep soil profiles in residual soils originating from the slowly weathering sedimentary rocks can be explained by gravitational slide.

To sum up: The soils derived from the sedimentary rocks (S.1, S.2 and S.3) are agriculturally inferior to those derived from the igneous rocks (D.1, D.2 and D.3). They are generally shallower, more acidic, contain fewer plant nutrients, are more prone to wind and water erosion, and due to inadequate drainage, may be waterlogged during rainy seasons. The doleritic soils, on the other hand, generally stand up better to maltreatment, due mainly to their favourable structure. They carry, as a rule, sweetveld. The alluvial soils (A and A-C) are generally the most fertile and are most sought after by the Natives.

2.—ARABLE LANDS

A large percentage of the available soil in the Keiskammahoek District has been converted into arable lands. Aerial photographs of the district give an impression of the extent to which the soils have been put under the plough. Steep slopes up the beautiful valleys of the Wolf, Mnyameni and Chatha streams have been cultivated. These lands and others on equally precipitous slopes, have suffered badly from erosion. Scars along the mountainsides indicate the presence of lands that have been long abandoned. Fortunately, large blocks which have been proclaimed forestry areas have escaped the ravages of Native cultivation.

There are, however, other lands on more gentle slopes and on deeper soil which have been better preserved. When it is considered that they have been under mono-culture for so long (almost 100 years) the extent of erosion is not as severe as might be expected. The lands on the commonage, belonging mostly to Europeans are altogether superior to those in the locations.

The yields from the Native lands are disappointing, if the nature of the soil and the average annual rainfall are taken into consideration. This poor yield, estimated at less than one bag of mealies per acre, would seem to indicate that the plant foods in the soil are depleted.

The Native Affairs Department, however, has done much good work in the locations, most of which have accepted the Betterment Scheme. The Agricultural Officers have by their efforts achieved great improvements in the Native lands. They have contoured a large percentage of the lands and insisted on grass strips along the contours. Besides recommending and assisting in the construction of anti-erosion works, they have aided the Native land-owner by carting manure on to the lands at a nominal fee. Grass experiments have been started to determine which species will answer most satisfactorily under the prevailing climatic conditions. Vegetable growing has been encouraged.

The presence of such institutions as the Fort Cox Agricultural College and the St. Matthews College within the district, has undoubtedly had a beneficial effect on the farming community.

3.—IRRIGATION SCHEMES

Keiskammahoek District is well supplied with perennial streams, and much water is available for irrigation purposes. There are, however, only a few irrigation schemes in existence and these are mostly owned or controlled by Europeans. There are, for instance, irrigation schemes on Fort Cox, St. Matthews, on the Keiskammahoek commonage and at the junction of the Chatha and Mnyameni streams. The existence elsewhere of furrows in various stages of disrepair proves that some irrigation schemes have been abandoned. The existing schemes are used mostly for the cultivation of fruit and cattle feeds.

The scheme at St. Matthews is used for producing food for the resident scholars as well as for cattle feed. There is a movement afoot to replace the ordinary irrigation by spray irrigation. This is indeed a laudable project because the advantages of spray irrigation are many. Overhead irrigation is more economical on water, which fact minimises the danger of water-logging, especially at St. Matthews where the internal drainage is not always favourable. Water is also more easily applied from sprays where the surface is undulating and reverse slopes from the river bank are not uncommon.

4.—RECOMMENDATIONS

(a) Arable Lands

There are many lands in the Keiskammahoek District which are economically not worth cultivating. These are the lands on the steep slopes of the main valleys and their tributaries. The steep gradient combined with, more often than not, inferior soil, makes the cultivation of these lands a danger to the very existence of the soil.

It were far better if these lands were to revert to natural vegetation, or alternatively that new grass species, rich in feeding values, were established there. The higher reaches of all these valleys constitute the source of the water which flows down the many streams. By restoring and protecting the natural vegetation in these areas, the water supply will be appreciably augmented and maintined during the dry winter months. In this way more water will be available for more and larger irrigation schemes, referred to later.

Only the lands on good deep soil and on a more level gradient should be cultivated. There are large blocks of suitable soil along the

Mthwaku River and the lower reaches of its many tributaries, in the Gwili-Gwili, Rabula, Nqhumeya, Burnshill, Lenye and Gxulu locations, to mention only the most important ones. These lands should be cultivated intensively, with the application of a suitable crop rotation of which grass leys form an essential part. Fertiliser and manure should be applied judiciously and the making and the application of compost should be encouraged. If the good work started by the Agricultural Officers is carried on, the yields from these selected lands will exceed the total yields gleaned from all the lands at present.

(*b*) Irrigation Schemes

With the meagre data available at present it is impossible to state how much land can be brought under irrigation. Water gauges on ten of the main streams were installed by the Irrigation Department two years ago. The information obtained from these will be invaluable in estimating the strength and the continuity of flow of each stream.

Apart from the existing schemes there are certain areas which hold out possibilities for irrigation.

(i) Below the junction of the Chatha and the Mnyameni streams there is a large block of land on the right bank of tne Gxulu River suitable for irrigation. Water could be obtained from either or both streams.

(ii) Below the confluence of the Lenye stream with the Keiskamma River on the right bank of the latter river there is some good level soil which extends far downstream.

(iii) Another suitable spot is on the left bank of the Rabula River just below its confluence with the Zanyokwe stream.

(iv) Lastly, another area on the right bank of the Keiskamma River just below its confluence with the Wolf River may be irrigated from the latter river. This is one of the abandoned schemes.

In all four cases the soil seems fairly level and is deep with good drainage. The streams from which the water will be tapped are the strongest in the district. Records from the gauges will show whether the flow throughout the winter months is sufficient to maintain an

irrigation scheme or whether storage dams will have to be constructed. Before, however, any irrigation schemes are embarked upon, the areas under discussion must be contour surveyed to ascertain how much land can be commanded economically.

The yields from the irrigation schemes will augment those from the arable lands.

5.—MAPPING

Owing to the absence of an accurate published map it was decided to use the plan prepared by Professor Mountain of Rhodes University for his Geological Survey.

This plan appears to be fairly accurate, but the scale (1 inch equals 1 mile) is too small for mapping accurately the different soil types. The soils in the Keiskammahoek District vary appreciably and it would be impossible to indicate every change from type to type on the plan provided. The boundaries given on the plan do not necessarily indicate the line of demarcation from one type to another; they merely indicate on broad lines what soil types are to be expected in different localities.

The geological map, constructed by Professor Mountain, proved very useful in determining the soil types from the geological formations. The author takes this opportunity of expressing his acknowledgement of much useful information gleaned from the geological plan.

The different soil types have been mapped on the accompanying plan. The legend on the plan gives the significance of the different shades.

An attempt has been made to indicate on the plan the extent of erosion. The symbols E1, E2, E3 and E4 represent severity of erosion in increasing degree.

The results of the chemical and mechanical analyses are tabulated in the annexure.

(2) Results of the Mechanical Analysis of the Type Samples

SOIL TYPE	Depth (inches)	Coarse sand 0.2 mm.	Fine sand 0.2-.02 mm.	Silt 0.02--0.002 mm.	Clay 0.002 mm.	$CaCO_3$	TOTAL
Deep red clay D.2	0- 6	1.0	45.2	21.9	30.7	0.0	98.8
	6-12	1.0	42,8	20.1	37.1	0.0	101.0
	12-24	1.0	39.7	16.9	42.1	0.0	99.7
	24-36	1.2	36.2	20.0	43.2	0.0	100.6
	36-54	1.0	28.3	12.7	59.2	0.0	101.1
Alluvial A	0-12	4.2	55.2	18.8	22.1	0.0	100.3
	12-24	2.4	43.6	21.4	32.0	0.0	99.4
	24-36	0.9	25.6	26.1	45.2	0.0	97.8
	36-48	0.0	17.4	27.6	52.9	0.0	97.9
	48-60	0.0	11.5	29.0	57.1	0.0	97.6

A BOTANICAL SURVEY OF THE KEISKAMMAHOEK DISTRICT

(Summary of Botanical Survey Memoir No. 27)

by

R. STORY

Introduction

The vegetation was studied with two objects in view, firstly to classify and describe the various plant communities, and secondly to investigate the reasons which might cause their vigour or decline.

It was found convenient to divide the vegetation into woodland comprising seven different types, and grassland comprising two. The woodland types were :—

1. Scrub of *Acacia karroo.*
2. Low mixed scrub, as found at Fort Cox.
3. Tall mixed scrub, as found at Nqhumeya.
4. Bush, as found at Zanyokwe.
5. Dry forest, as found at Lenye Forest Station.
6. Moist forest, as found at Wolf Ridge Forest Station.
7. Macchia.

The grassland types were :—

1. Sweetveld, palatable in winter and summer.
2. Sourveld, palatable in summer only.

Climate

The truth of the widely-held view that vegetation is affected by the climate more than by any other influence soon became apparent, and for this reason the Division of Meteorology was approached for help in establishing a series of five small stations at which investigations could be carried out on moisture and temperature, which are generally held to have the greatest bearing on plant distribution. The results of the investigations are summarised in the notes which follow.

MOISTURE

Rainfall

The rainfall for the past eighteen years was investigated from the records of ten gauges situated at various points in and near the district. They showed that an average annual rainfall of about 25 inches or below was associated with bush and scrub, and that dry forest and wet forest required about 30 and 35 inches respectively. The dividing line between sourveld (in the moist areas) and sweetveld (in the dry areas) was near the 25-inch isohyet. Irrespective of the amount of yearly rainfall, which varied from 61 inches at Evelyn Valley to 24 inches at Fort Cox, about 70 per cent fell during the summer (October to March inclusive). At all the gauges, but particularly at those in the drier areas, the rainfall fluctuated widely from year to year.

Humidity

Of the five stations mentioned, two were established in the highlands at about 5,000 feet, two in the lowlands at about 2,000 feet, and one between them in the forest zone at 4,000 feet. Two-hourly readings of the humidity were taken at each station on 178 complete days, spread over one year. Because of this short period, they are comparable among themselves only (as are the temperature records) and cannot stand alone. The results were expressed as the *saturation deficit*. Surprisingly little difference was apparent between the readings from the lowland and highland stations.

TEMPERATURE

Temperature readings at the five stations were taken at the same intervals as those for humidity, but on 233 days instead of 178.

Average Temperature

The two highland stations were consistently the coldest of the five, and the two lowland stations were usually the warmest.

Temperature Range.

This was least in the highlands, where the temperatures were on the whole cool and even. In the lowlands they were warm and fluctuating. At all stations the summer rise of temperature began in December and the winter drop in May.

Minimum Temperature

This was generally about six degrees lower in the highlands than in the lowlands, with the moist forest intermediate. In the highlands, midnight was the commonest time of occurrence of the minimum temperature. The next most common occurrences were in the morning round five or six o'clock. In the lowlands there was likewise a concentration of minimum temperatures at midnight, but less so than in the highlands. On the other hand, the occurrences in the morning were decidedly more common, and slightly later.

Maximum Temperature

The lowland maximum was usually about 15 degrees higher than the maximum in the highlands. At all stations, the maxima occurred mainly in the early afternoon, round 2 p.m., but at the two highland stations there was an additional grouping of them at and near midnight.

Possible explanations for the groupings of maximum and minimum temperatures are discussed in the original paper.

Woodland

TYPE I—ACACIA SCRUB

From photographs, historical records (which mention its encroachment as far back as 1894) and the proportion of old to young trees, it is clear that Acacia scrub is rapidly spreading into areas which were formerly grassland. This is a major farming problem over most of that part of the Eastern Cape Province which is below 3,000 feet in altitude, and in many low-lying parts of Natal and the Transvaal as well. The fact that *Acacia karroo* is South Africa's most widely-distributed tree suggests that it is the least exacting in its demands, and that it would therefore often be the first to migrate into an area unfavourable to trees. 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—as far as such areas were not too unfavourable to preclude its growth completely. Thus the presence of homogeneous and stable Acacia thickets indicates not an area suited to vigorous tree growth, but one where healthy grasslands might be maintained.

Experiments have shown that Acacia grows much better in the absence of grass competition, and the behaviour of Acacia communities, in general, indicates that grass acts almost like a protective skin which has to be ruptured before the Acacia can grow. This gives support to the widely-held view that uncontrolled grazing, and the consequent destruction of the grass cover, are the basic causes of scrub encroachment, and although the tree has many uses, it is, in the form of scrub, a pest which occupies ground that could be occupied by grass of far greater value both for fodder and as a protection to the soil.

There is with decreasing rainfall a limit beyond which Acacia cannot normally exist, and it can be expected to disappear from the landscape in general between the 20-inch and 15-inch isohyets. Where the rainfall is below 15 inches it can continue growing along water-courses and at the sides of roads, where excess water collects, but where the annual rainfall is less than five inches it is usually completely absent. It does not appear to be adversely affected by a high rainfall.

It cannot stand cold winters, as is shown by its absence or scarcity in the region bounded by Johannesburg, Belfast, Harrismith, Maclear, Cala, Middelburg, Sutherland, De Aar, Bloemfontein and Kroonstad. The temperature map shows this region to be the coldest part of the Union. High temperatures, however, do not appear to limit its distribution.

It is attacked by a great number of natural enemies, of which weevil are among the most important so far observed. They destroy nearly a quarter of the seed crop. Because of the combination of hazards that endanger the seeds and seedlings, about 2,500 seeds must be produced for each seedling that becomes established. Counts indicate that the larger trees may be expected to produce an average of about 19,000 seeds a year, and that the crop may be heavier in dry years. The seeds are spread by cattle certainly, and probably by birds as well, but the most important agents of distribution are strong winds, which in the Eastern Cape blow mostly from the west.

Between 80 and 90 per cent of the seeds are viable. Some of them germinate within a few days, but in each sample there is a proportion which remains dormant even when kept constantly damp. Germination in this proportion continues slowly for three years at least, and it appears that the impermeability of the seed coat is the only reason for the delay. Seeds will germinate normally when they are still soft and green, and if stored in a dry place some will remain viable for 57 years at least. Because of the delay in germination, it is not possible to give accurate figures for the rate of germination in the field. Veld fires cause a sudden abundance of seedlings, but because some are damaged by the burn, the final number of seedlings is likely to be lower than it would normally be.

It is difficult to kill seedlings by burning after they have grown about 14 inches high, and in spite of statements to the contrary, experiments indicate that goats take grass by preference, and that they will not keep ground free of Acacia scrub without seriously damaging the veld. Except when the seedlings are very young, both these methods will tend to thicken the scrub by encouraging the growth of coppice shoots.

TYPE 2—FORT COX SCRUB

This is a mixed and thorny type of woodland between seven and ten feet high, grayish in colour and found where the rainfall averages about 23 inches a year. It may form thickets or the bushes may be scattered, with Digitaria, Panicum, Themeda and Cymbopogon making up the grass cover between them. Tree Euphorbias are common. The trees are too small to yield any useful timber, and their chief economic use is in providing firewood, or browsing for stock. It is good cattle country, and can maintain cattle through the winter without their losing condition, but with uncontrolled grazing it deteriorates, because the scrub tends to thicken and to encroach on all the open spaces.

TYPE 3—NQHUMEYA SCRUB

The scrub of this type is taller, denser and greener than in type 2, and has fewer spiny plants. Tree Euphorbias are present but uncommon, and although the trees are again too small to yield any useful timber, timber species like White Pear (*Apodytes dimidiata*), White Ironwood (*Vepris lanceolata*) and Sneezewood (*Ptaeroxylon obliquum*) are present in fair quantity. The average height of the trees is a little over 12 feet and the diameter a little over two inches. Grassy glades, containing the same species as those of type 2, are prominent. The effects of uncontrolled stocking are similar to those obtaining in type 2—that is, the scrub thickens and encroaches on the grassy spaces.

TYPE 4—ZANYOKWE BUSH

Open spaces are not found in type 4, which is nearer to forest than the preceding types. It has an unbroken canopy between 20 and 25 feet above ground level, and larger numbers of broad-leafed trees. Tree Euphorbias occur as small and rare communities towards the margin of the bush only. A species of Cycad makes its appearance, and so do several trees foreign to the drier types. Most of the trees support a dense growth of lichens. Flowering plants and ferns also occur as epiphytes, and climbing plants are common. There is a little light timber from trees of Boerboon (*Schotia latifolia*), Cape Chestnut (*Calodendrum capense*), Kaffir Plum (*Harpephyllum caffrum*), Yellow-wood (*Podocarpus spp.*), Red Currant (*Rhus legati*), Thorn Pear (*Scolopia spp.*) and White Ironwood (*Vepris lanceolata*), but in general the use of this type remains restricted to wattles, firewood and browsing for cattle.

TYPE 5—DRY FOREST

As distinct from the first four, type 5 may be taken as true forest, although a dry form of it. It does not occur where the rainfall is below about 29 inches a year. The level of the canopy is 40 feet more or less, but the average height of all the trees is about half that. Lianes of many species are numerous, several plants that have a bushy habit in the drier types changing here into creepers or scramblers. Epiphytes are abundant throughout. There is a deep layer of leaf mould and a dense undergrowth in which practically the only grasses are the forest species *Oplismenus hirtellus* and *Stipa dregeana*.

At altitudes up to about 2,500 feet the commonest pioneer of this type is Acacia, which gives protection and shelter to seedling forest trees, and these in turn grow up, shading and killing the Acacia in the process, and spreading outward until they merge and form an unbroken community.

Most of the trees in type 5 are not thorny and are readily eaten by stock; consequently uncontrolled grazing tends to destroy the forest instead of thickening it as it thickens the drier types.

TYPE 6—MOIST FOREST

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, the highland macchia excepted. The height of the canopy is about 50 feet, rising in places to 70 and over where the best specimens grow of Yellow-wood (*Podocarpus spp.*) and Black Ironwood (*Olea laurifolia*), but nearly half the trees are Onderbos

(*Trichocladus ellipticus*), a small species that does not reach the canopy. The undergrowth is rich in sappy plants and ferns, grasses and sedges being of minor importance. The ground is usually damp and covered with humus, and perennial streams run down all the larger kloofs.

Acacia is not found on the margins of this type. Boekenhout (*Rapanea melanophloeos*) is the commonest of many that can grow in the open, all of which are theoretically 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. Otherwise, cattle congregate beneath them for shelter, and in doing so effectually prevent the establishment of a new generation of seedlings.

TYPE 7—MACCHIA

Macchia or fynbos is a general term for short evergreen bushes with small and hard leaves. It covers large areas of the Keiskammahoek District between the forest patches and above them, and is made up of numbers of different species of bushes, most of them superficially very much alike. There are three important ones which between them make up the bulk of the macchia—*Cliffortia linearifolia* where the altitude is below 4,000 feet, *Cliffortia paucistaminea* and *Erica brownleeae* where it is above 4,000 feet.

Cliffortia linearifolia

This species usually grows about three feet high. It cannot exist where the rainfall is under about 30 inches a year, and although always closely associated with the forests it is never found inside them, for strong light is essential to its healthy growth. It flowers abundantly at all times of the year, nor is there any lack of seedlings in the community wherever the light is adequate.

If there is sufficient grass, *Cliffortia linearifolia* is avoided by stock and is able to flower and set seed unchecked, but the 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 spread of the Cliffortia seedlings, and a dense stand of macchia becomes established much more quickly. When once this has happened, it is useless to try to eradicate the bushes by grazing alone. They must be killed by chopping or burning, then when the area has been cleared, they can be prevented from returning by controlled grazing. This subject is treated in more detail in the main paper.

The evidence so far collected is that *Cliffortia linearifolia* is successionally more advanced than the grasses, but that it is nevertheless not a climax community except probably in exposed places. Where there is shelter, it gives way to forest.

Cliffortia paucistaminea and *Erica brownleeae*

These two plants are so alike in their behaviour that they are conveniently considered together. They occur from the peaks of the Amatole Range down to an altitude of about 4,000 feet, sometimes scattered, but more often in dense impenetrable masses with a deep layer of trash beneath them. Their height is usually about five feet, and their growth most luxuriant on the south-facing slopes. The ground they occupy is shared more or less equally between them. Like *Cliffortia linearifolia*, they cannot tolerate shade, and tend to become established more easily in places where the grass cover has been removed or weakened, but given time they will encroach even upon well-managed or protected grassland. They set seed and germinate in such abundance that burning is the only practicable method of checking them—and checking them is necessary on grazing grounds, for cattle eat them only in times of great scarcity and reluctantly even then.

As the community is most inflammable, periodic disastrous fires must be regarded as inevitable in macchia country. They leave the ground they traverse totally bare, but if the weather is favourable a new cover of plants springs up surprisingly quickly, grasses and herbs showing up within a month and macchia (in the form of seedlings) within four. The areas that were under the densest macchia are the last to recover, firstly because dense macchia has an exceedingly meagre growth of plants beneath it, and secondly because the greater heat of the fire in such places destroys most of what seed there is. Unlike the grasses, macchia is killed by a hot fire, regeneration being nearly always from seed.

If the mountain slopes south of the escarpment and above the forests are protected from fire, the indications are that the grassland areas on them will change to macchia, with possible exceptions in the most windswept places. This is shown, besides by the behaviour of protected plots of grassland, by the records of surveyors and by the presence of macchia in a certain part of the mountains inaccessible to cattle and out of reach of the mountain fires except when chance firebrands are blown in by strong winds.

Contradictory evidence is given by numbers of people who knew the Amatole Mountains during the last century or in the early days of this, and who state that the mountains were then pure grassland. This paradox may be explained by a record made by Hutchins in 1887, when he was Conservator of Forests with headquarters in Kingwilliamstown: "Above the natural forests on the Amatola and Pirie ranges are extensive tracts of waste mountain land which burns annually in fierce fires and is every winter a source of anxiety to those in charge of the forest below." Fires are the surest force in checking the spread of macchia, and it is suggested that the history of the vegetation 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, the fire-resistant grasslands obtained a footing, and spread until the macchia was confined to the spots where fires could not easily penetrate. It was when they were in this condition that the mountains were first known to Europeans. As the country became settled and as the people and their stock increased, the grasslands were cropped short and fires became weaker and less frequent, until the macchia was able to increase again and re-establish itself over much of its former home.

Except where basins and gorges provide shelter, and except for stunted individuals here and there, forest trees are a rarity in the highland macchia, and even in the sheltered spots mentioned, forest patches are composed of seldom more than eight species, usually the same in all the patches and in addition known for their tolerance of unfavourable conditions. Other evidence which cannot be discussed here also suggests that the upper slopes of the Amatole Mountains are unfavourable to the establishment of natural forest, and that the macchia is probably the climax in these parts.

Grassland

The grasslands fall naturally into two great classes, that in the warm areas with a low rainfall being known as the sweetveld, and that in the cooler and wetter areas as the sourveld. The essential difference between them is that the sweetveld is palatable in winter as well as in summer, and the sourveld palatable in summer only. The sourveld is made up of tall bunched grasses vigorous in growth,

those in the sweetveld being smaller and low-growing, and usually mixed with thorny scrub.

Sweetveld

Most of the sweetveld has been badly treated in the past and has changed greatly from the original mixture of Rooigras (Themeda), Finger Grass (Digitaria) and Buffalo Grass (Panicum) which is the rule in well-managed or protected areas. Panicum and Themeda are usually the first to go when conditions change for the worse. Digitaria manages to exist together with the Eragrostis and Sporobolus which take their place, and these three usually remain until conditions are so bad that they yield their places to Cynodon (Kweekgras) and Karroo shrublets.

Large communities of weeds are a feature of ruined sweetveld, the commonest being several species of Senecio, *Bulbine asphodeloides* and Chincherinchee (*Ornithogalum thyrsoides*). There is proof that uncontrolled grazing increases the Ornithogalum out of all proportion to its normal incidence in the veld, and strong evidence that this is true also of Bulbine and Senecio. The Ornithogalum and many Senecios are poisonous, but as they are avoided by stock they seldom cause losses.

Sourveld

At the lower limits of the sourveld, that is near the sweetveld zone, the dominant grass is Themeda. With increasing rainfall, a mixture of other grasses and herbs makes an appearance, and in its typical form the sourveld has a much richer flora than the sweetveld in respect both of grasses and non-grasses. Themeda, however, is a member of the sourveld even in the highest and wettest parts of the mountains, and although it is by comparison normally uncommon there, hard grazing tends to encourage it at the expense of the other grasses. If this is continued, the Themeda becomes gradually scarcer again and *Sporobolus capensis* and *Sporobolus centrifugus*, together with their close allies, gain the ascendency. The last stage is when the weakened grasses become covered by a mat of the well-known *Helichrysum argyrophyllum* which was investigated by Schonland in the early 1920's. He showed that it was not an aggressive weed, that its spread was due solely to uncontrolled grazing, and that the grass could easily be brought back into Helichrysum areas. The information is contained in his pamphlet of 1927. The presence of this hardy plant, which Schonland called "a blessing in disguise," prevents the formation of bare areas, for it persists and protects the soil in all but very heavily trampled parts.

The Relation of Grassland to Woodland

It is a matter of common knowledge that the water requirements of thorny scrub are less than those of the forest which occupies the mountain slopes above it, but it is not so generally known that the macchia also is a more xerophytic type of vegetation than the forest. This is shown not only by its anatomical structure but also by its behaviour, and there is general agreement on the soundness of this view among most writers who deal with its distribution.

As to the reason for its occurrence on the Amatole highlands, with their cool and misty climate and abundant rainfall, there are many authors whose work goes to show that the influence of the moist conditions at high altitudes may be greatly lessened by other forces which make the water unavailable to the plant. At high altitudes in general, winds are stronger, the solar radiation is more intense and the atmospheric pressure less, and these three forces cause an increase in the water-loss of the plants growing there. In addition, the soils in the Keiskammahoek highlands have a peaty texture and are often frozen in winter—two further causes of physiological drought. At times, therefore, conditions on the mountains are unfavourable to plant growth, and it is the xerophytic macchia which can better withstand their severity than the trees.

Of all the unfavourable forces mentioned, wind by its drying effect appears to be the most harmful to trees. For this reason they establish themselves only with the greatest difficulty where shelter is lacking, and accordingly grass, which is less affected by reason of its low growth form, is often the dominant community on flats, plateaus, ridges and buttress slopes. 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.

Economic Botany

Even a superficial examination shows unmistakably that with the exception of the Crown forests, the vegetation of the whole district has undergone a profound change for the worse within the last hundred years. Records from newspapers and Government files report abundance before 1890, and scarcity after 1910, from which one may deduce that the beginning of this century was the likely turning-point in the composition of the veld.

By controlled grazing, improved methods of agriculture and the clearing of useless vegetation there is no doubt that the district could support many more people than it does at present, and that without the deterioration of soil and vegetation that is at present going on. This, however, may not be the complete solution to the problem, for history shows that there has been a very large increase in the population during the past hundred years, and although one cannot with certainty predict a like increase in the future, the possibility is one that should not be summarily dismissed. 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 consideration should be given to the needs of a possibly larger population.

Methods of reclamation have been touched on in the main paper but not discussed in detail, for they are well known to the staff of the Native Affairs Department and are being put into practice by them. As to the future policy, it is suggested that the following points should be borne in mind:—

Sweetveld

1. Resting, followed by controlled grazing, should be the main method of restoring the original grass cover. Reseeding is not considered necessary at present.

2. Scrub clearing, although it will make way for pastures with a higher carrying capacity, should not be attempted before the area has been fenced into camps, for great harm may be done by removing even noxious vegetation if uncontrolled grazing permits nothing to take its place. Clearing, especially of Acacia scrub, should begin from the west, to avoid infestation of cleared ground by fresh seed.

3. The possibilities for irrigation should be explored, and attention given to the aspect of land before it is brought under cultivation. North-western and western slopes should be avoided, for they face the sun when the temperature is at its maximum.

4. Stream banks should be protected as far as possible from cultivation and grazing.

Sourveld

1. The precipitous slopes at the headwaters of the Chatha River should be closed to grazing except in times of emergency.

2. In spite of its uselessness for grazing, macchia forms an excellent protection for the soil. The abuse of grassland constitutes so serious a menace to the people of the district and to others who are dependant on 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 the grazing.

3. When taken in hand, the eradication of macchia could probably best be done by burning parts along the contours in rotation, season by season, and in descending order to prevent re-infestation by seed washed down from above. The unburnt parts would check the run-off from the burnt areas.

4. Because macchia is probably the climax on the Amatole highlands, and because it is unpalatable to stock, the occasional use of fire must form part of any plan which aims at the maintenance of a grass cover in the sourveld of the Keiskamma basin.

VEGETATION AT RIVER SOURCES

An Investigation of the Sources of the Keiskamma River (Amatole Mountains)

by

R. LINDSAY ROBB

The investigation described in this paper, forms part of a comprehensive survey into all aspects of Native life and welfare in the District of Keiskammahoek which has been carried out by the National Council for Social Research. This particular investigation would not have been possible without the assistance and fullest co-operation of the Department of Native Affairs. The Department sub-divided the area—approximately 3,000 acres—into four camps in 1945, but owing to staff difficulties due to war conditions it was not possible to exercise full control of the grazing until 1948. The area is under the administrative control of the Native Commissioner, Alice, Mr. T. D. Cordingley and the burning and fencing of additional grazing plots was done by Messrs. J. E. Puttick and A. Hamann of the Agricultural Staff, Native Affairs Department, Alice.

A botanical survey of the area was carried out by Mr. R. Story, National Botanical Survey, and the botanical analysis of the grazing and fertilised plots was carried out by Mr. J. H. Kotsokoane (post-graduate student), Witwatersrand University. The gauges and water-table apparatus were supplied and installed by the Irrigation Department, and the weekly measurements recorded by Mr. G. K. McCune of the Native Affairs Department, seconded to Rural Survey. For these valuable services, and for advice and constructive criticism from Mr. C. V. Pienaar, Dohne Pasture Research Station, Dr. J. W. Rowland, Division of Research and Education, Department of Agriculture, Dr. R. L. Davidson, Witwatersrand University, and Mr. R. Baker,

Native Affairs Department, I wish to express my sincere thanks and appreciation.

This investigation is by no means completed, as will be apparent from the paper, and its continuation for a number of years is highly necessary, but in view of the striking results already obtained and the far-reaching possibilities of their application to other areas, delay in the publication of the information now available would not be justified.

The key to rehabilitation of the District of Keiskammahoek and large areas beyond lies in the restoration of the vegetation on the Amatole Mountains and its effective control afterwards. This mountain range, which rises to a height of 6,360 feet at Hogsback, has a high annual rainfall and is the source of many important streams and rivers. It also forms the watershed of a large and potentially productive region.

Surveys carried out during the last two years have revealed that serious deterioration of the vegetation on a vast scale has occurred during the last half century. The grass on " sponge " areas, which are Nature's collectors of rain-water to supply the springs, streams, rivers, etc., has been eaten and trampled out, and many of the streams which would normally feed the rivers have dried up. Exposure of the soil to the wind and the rain, where immediate replacement of the denuded grass sward by other vegetation did not take place, has resulted in erosion of varying degrees of severity.

Schonland[1] (1927) states :—

> It has been roughly estimated that over sixty square miles of previously excellent pasturage has been more or less taken possession of by an everlasting, *Helichrysum argyrophyllum*, locally known as "Amatola weed," which even a hungry goat will not touch. Mr. E. B. Dwyer, Conservator of Forests, Kingwilliamstown, wrote to me in 1922: "I was stationed at Keiskama Hoek from 1889-1893, and the areas now affected were then stretches of waving rooigras in autumn and the paths up from Mnyameni to the ground behind were scarcely visible from below."

The resulting losses cannot, of course, be accurately assessed, but their severity and significance are beyond all doubt. The grazing over a vast area has been almost completely destroyed, millions of gallons of water have been swept into the sea in flooded rivers and lost through lack of vegetation to hold the rain as it fell, and it is on these areas that the highest rainfall occurs ; the underground sources

[1]Schonland, S., " Reclamation of Ruined Pasturage on the Amatolas," *Science Bulletin* No. 55, 1927.

have been deprived of their natural sources of replenishment, thousands of tons of soil have been carried away by the wind and in the flooded muddy rivers after heavy rains, and the decline in fertility through losses of grass, water and soil marks the culmination of a long period of neglect and mismanagement.

According to reliable information from various sources, the vegetation on the mountain range, 50 years ago, consisted mainly of rooigras (*Themeda triandra*), and was said to have an exceptionally high stock-carrying capacity[1]—two to three cattle per acre for seven to eight months of the year. This apparently was a common rate of stocking on the mountain grassland in those days and it may well be that this was accepted as the *stock-carrying capacity*.

There is a fundamental difference between " rate of stocking " and " stock-carrying capacity," and there is still great confusion between the terms and urgent need for their clarification. In the utilisation of the natural veld the prime consideration is not how much beef, milk, mutton or wool we can produce ; the prime consideration is what we can produce of these animal products without detriment to the vegetation in performing its major function of holding the soil and the water. This is of supreme importance ; it is in fact the corner-stone in veld management.

Stock-carrying capacity means the number of animals that can be supported on a given area—for their particular needs—without lowering the capacity of the vegetation to hold the soil and the water. *Rate of stocking* is simply the number of animals on a given area and may be quite regardless (in fact often is) of the major consideration.

It is clear beyond all doubt that the rate of stocking on the Amatoles during the last 50 years has been in excess of the *carrying capacity* of the vegetation and this, in conjunction with indiscriminate burning and lack of control of the movements of the grazing animals, has resulted in a complete breakdown of the original rooigras sward and its replacement by helichrysum and fynbos over wide areas.

Helichrysum has invaded the higher altitudes above the forest level and now extends over a very large area of the mountain range. Above 3,000 feet altitude it is abundant on the warm dry slopes which appear to provide the most suitable conditions for its establishment and development, but it has not invaded the moist and shady areas.

[1]Keet, J. D., *Memorandum on the Keiskama River Catchment.*

It is a common belief among farmers that helichrysum can invade their land from adjoining areas where it is abundant. This is only a half truth and therefore very misleading, and clarification is necessary. Helichrysum *cannot* invade veld or other grassland unless the turf is broken through over-grazing, cattle-tracks and fire-breaks, etc. It never invades well managed veld and no one need fear its introduction from adjoining infested areas so long as the sward remain unbroken.

Fynbos has also invaded the mountain range on an extensive scale from Hogsback round to Gwili-Gwili and Charybdis. It invades damaged grassland on areas too moist for helichrysum and is most commonly found on the higher altitudes where moisture conditions and shade are unfavourable for helichrysum. On the moister areas fynbos becomes very thick and almost impenetrable but more open under drier conditions. There are transition areas on Wolf Plateau and Mount Thomas where conditions are partially suitable for both helichrysum and fynbos and they are found together.

The primary function of all natural vegetation is to hold the soil and water and it is imperative that its utilisation and management be based on this major consideration. This applies even more forcibly to mountain-ranges—watersheds—than to less steep country of lower altitude. The highest precipitation of rain occurs on the mountains which are our main sources of water supplies. If there is adequate, properly managed, plant cover on these regions the rain is held where it falls; the plants are provided with their moisture requirements and the balance not lost in transpiration and evaporation seeps down to feed the springs and streams—river-sources—and the underground supplies.

Until effective measures are applied for the restoration and maintenance of the vegetation of this highly vulnerable watershed region, not only the District of Keiskammahoek but all other areas dependent on this source for water must inevitably become more arid, with the rainfall of each succeeding year appearing to diminish because it will be less and less effective.

If it is accepted—and it can hardly be disputed—that the major function of a mountain vegetation is to hold the soil and the water, with provision of grazing for stock a secondary consideration, then the problem of restoration and future maintenance should be approached from this angle. And from this it follows naturally that the existing vegetation of fynbos and helichrysum must be considered mainly

in relation to capacity or incapacity for holding soil and water—the first and major function of a watershed vegetation.

If this function were being adequately performed the problem would be a simple one of fencing to protect the area from livestock—leaving for a moment consideration of the secondary function of providing suitable grazing.

But this survey of the Amatoles revealed clearly that fynbos and helichrysum are not adequately performing the function of a watershed vegetation. They do not provide a sufficiently dense cover to hold all the rain as it falls; there are too many open spaces exposing the bare soil, and erosion through run-off is inevitable, varying in severity with the steepness of the land. Losses of soil and water are taking place, and we cannot afford to lose either. The contribution to grazing is practically nil, since helichrysum is inedible to stock and fynbos is only nibbled under stress of hunger when there is nothing else to eat.

This calls for action to eradicate the existing vegetation and replace it by a grass sward of the type which dominated the mountain range 50 years ago. A dense grass cover will hold all the rain as it falls and prevent erosion of the soil which will no longer be exposed to the wind and the rain but firmly held by millions of plant rootlets. A grass sward may also contribute something for the grazing animals and for the rebuilding of soil fertility lost during the last 50 years through wind and water erosion.

We are singularly fortunate in that some valuable data were available on helichrysum eradication. A quarter of a century ago the late Dr. Schonland, Professor of Botany at Rhodes University College, observed that invasion of helichrysum was taking place over wide areas on the Amatoles, and he set out to find the causes and, if possible, ways and means of destroying it and restoring the original grass vegetation.

Schonland[1] found that helichrysum invasion followed the destruction of the grass sward through overgrazing and indiscriminate burning, and this was even more in evidence where overgrazing took place *after* burning. Owing to what he termed a fortunate accident, Schonland made some important discoveries. About a quarter of his

[1]Schonland, S., *Ibid.*

experimental plot (ten acres) in the Gxulu Location beyond the Gweleka Forest was accidentally burned by a fire started by the Natives outside. This provided him with burned and unburned veld within the experimental plot—fenced and under control—for comparison with burned and unburned veld outside, where no control was exercised

After 17 months' resting the burned portion within the enclosed experimental area exhibited a dense stand of grass, mainly rooigras, but the unburned portion remained helichrysum dominant with very little grass. Outside the fence on the burned uncontrolled area, overgrazing prevented re-establishment of the grass, and helichrysum remained dominant. On the unburned and protected area within the enclosure replacement of helichrysum by grass was so slow that Schonland could not even give an approximate estimate of the time when grass might again become dominant.

The results of Schonland's work have now been applied to an area of some 3,000 acres on the Yantolo Communal Grazing Reserve near the Hogsback Mountain which was heavily invaded by helichrysum and fynbos. The grass, formerly rooigras dominant, had been heavily overgrazed and trampled out and had virtually disappeared, and "sponge" areas with streams formerly feeding the Tyhume River, a tributary of the Keiskamma River, had dried up.

The procedure adopted by Schonland was followed, and the results he obtained have so far been repeated and confirmed. The whole area was rested for a year to induce as much growth as possible around the helichrysum, which is very resistant to fire, and it was burned at the end of the dry season—July-August, 1949. Helichrysum is so resistant to fire that it can only be successfully burned at the end of the dry winter season before the spring rains set in.

The destruction of helichrysum by fire should not be confused with the burning of grassveld. Experimental work on veld burning at various centres in South Africa has shown that the most satisfactory results are obtained by burning immediately after the first rains in spring and that deterioration of the vegetation results from burning in autumn. But a helichrysum infested area has little or no relationship to grass veld and it certainly could not be burned off after rain in spring.

The results obtained at the Hogsback followed the same pattern as those obtained by Schonland where good pasturage was restored within 18 months of protecting and resting the veld from grazing animals.

On the Hogsback area water was seeping through the grass-restored sponges into the small streams, also within six months from the time of burning the helichrysum. There is no doubt that on this area all the rain is now held as it falls by the dense grass cover, there is no longer any run-off from the surface and clear water is flowing freely from the formerly dried-up small streams into the Tyhume River.

But, although there are now sufficient data available to eradicate helichrysum successfully, there are still many problems requiring further investigation. It is not yet known what contribution—if any—the restored grass can make to grazing for stock without impairing its efficiency in holding the soil and the water which is the major consideration. Defoliation at different intensity levels and resting periods of varying duration call for further investigation, also the possible use of nitrogen to hasten a more rapid and complete restoration of the grasses. The problem in a nutshell once the helichrysum is removed is what use can be made of the herbage without in any way endangering the soil and water supplies.

The eradication of helichrysum must be preceded by fencing of the areas affected and followed by adequate protection from stock until the grass has been completely restored. And subsequent grazing must be so regulated and controlled that the stability of the vegetation as a water source is not impaired. The effect of failure to control the grazing following the restoration of the grass after eradication of helichrysum is now very effectively demonstrated on Schonland's experimental plot. The fences have been removed since 1946 and the plot has been subjected to the same overgrazing and burning since then as the surrounding uncontrolled area. The formerly reclaimed experimental plot is now just as helichrysum-dominant as the surrounding veld.

Fynbos, which also invades overgrazed and damaged grassland, is more difficult to eradicate than helichrysum but the procedure appears to be similar. Resting, followed by a fierce burn at the end of the dry season (July), will eradicate it, and the same care in protection and management afterwards is equally necessary as on treated helichrysum areas. But eradication, whether of helichrysum, fynbos or other undesirable plants, should be limited on the mountain range to areas of potential grazing only. Bearing in mind that the primary function of a watershed vegetation is to provide security of soil against erosion and stability as a water-source, and that the provision of grazing for stock is of a secondary importance, *no steep land* infested by helichrysum or fynbos should be burned. The exposure of steep slopes to erosion by burning off existing vegetation—whatever the type—is too dangerous, and particularly so on the areas of high rainfall. If the steep slopes on the mountains are protected from stock, they can well be left for natural revegetation as a protective agency in these vulnerable areas.

But it is not possible to consider the mountain vegetation as an isolated unit apart from the other grassland in the district. If the mountain vegetation is to be properly rehabilitated—and this is essential as a security measure against losses of soil and water, quite apart from any grazing potentialities—it will mean the withdrawal from grazing of large areas for prolonged periods. The mountain grassland should be considered primarily as a water source, with any possible contribution to grazing for livestock as of secondary importance.

At present the grazing for animals is so insignificant that *all the fenced areas* on the mountain range infested by helichrysum and fynbos should be closed to stock and prepared for reclamation on the basis of a watersource. The flat areas which offer additional possibilities for grazing should be burned off at the end of the dry season (July) and protected from stock afterwards until the grass has been restored.

The steep slopes should not be burned but protected and left for natural revegetation. While it is generally accepted that steep arable land should not be cultivated because of the danger of erosion, much less thought has been given to the grazing of steep hillside and mountain slopes although this practice has been the starting-point of much serious erosion. Anyone who takes the trouble to observe the movements of stock across steep slopes will notice how small chunks of turf are torn off by the feet of the grazing animals with exposure of the bare soil to sun, wind and rain. No grazing by heavy stock should ever be permitted under such conditions.

In April, 1950, eight months after burning, a botanical analysis of the treated and untreated areas was carried out. The aims of the analysis were :—

(*a*) To obtain a picture of the floristic composition of the areas.

(*b*) To investigate succession embracing the effects of over-grazing, trampling, erosion, burning and protection, colonisation of bare and patchy areas and competition.

(*c*) To determine the effects of fertilisers on the basal cover and changes in composition of the sward.

The following areas were analysed :—

1. Four half-acre plots lying within the experimental area of 3,000 acres. These plots are situated in typical veld and are fenced off from the general veld and from each other.
2. A small unfenced fertilised plot of 100 square yards and an adjacent unfertilised control.
3. One half-acre plot, unfenced, in the untreated helichrysum dominant area.
4. A fenced and protected plot of half an acre north-west of Chatha Forest Reserve for comparison with 1 and 2 above.

The percentage of the area covered by the herbage and the percentage of the total basal cover were worked out. The figures are based on the basal area concept and were obtained by means of the Bruce Levy Quadrat apparatus used in the manner described by West (1937) for determining basal area. There are many other methods of botanical analysis but this method, now widely adopted, gives the following information :—

(i) Total plant cover.
(ii) Total bare ground.
(iii) Species forming the plant cover.
(iv) Contribution of each species to the basal cover.

The results of the analyses are as follows :—

PLOT I.—Basal cover, 7 per cent—

Species :	*Themeda triandra*	approx.	28.8%
	Tristachya hispida	,,	21.6%
	Heteropogon contortus	,,	14.3%
	Aristida galpinii	,,	10.8%
	Eragrostis curvula	,,	7.2%
	Sporobolus centrifugus	,,	7.2%
	Elyonurus argenteus	,,	3.6%
	Harpechloa falx	,,	3.6%
	Trachypogon plumosus	,,	3.6%
	Andropogon appendiculatus	,,	3.6%

PLOT II.—Basal cover, 10 per cent—

Species :	*Themeda triandra* .. .. ,,	60 %
	Aristida galpinii .. .. ,,	17 %
	Tristachya hispida .. .. .. ,,	7.5%
	Harpechloa falx .. .. ,,	5.0%
	Heteropogon contortus .. .. .. ,,	2.5%
	Eragrostis curvula .. .. .. ,,	2.5%
	Eragrostis caesia .. .. .. ,,	2.5%
	Andropogon appendiculatus .. .. ,,	2.5%

PLOT III.—Basal cover, 11 per cent—

Species :	*Themeda triandra* .. .. ,,	41.4%
	Sporobolus centrifugus .. .. .. ,,	16.1%
	Eragrostis curvula .. .. .. ,,	16.1%
	Heteropogon contortus .. .. .. ,,	6.9%
	Tristachya hispida .. .. .. ,,	6.9%
	Aristida galpinii .. .. ,,	4.6%
	Harpechloa falx .. .. ,,	2.3%
	Andropogon appendiculatus .. .. ,,	2.3%
	Non-Gramineae—	
	Cliffortia paucistaminea .. .. ,,	2.3%
	Senecio species .. .. .. ,,	2.3%

PLOT IV.—Basal cover, 12 per cent—

Species :	*Eragrostis caesia* .. .. .. ,,	29.4%
	Themeda triandra .. .. ,,	23.1%
	Eragrostis curvula .. .. .. ,,	14.7%
	Aristida galpinii .. .. ,,	10.5%
	Sporobolus centrifugus .. .. .. ,,	8.4%
	Tristachya hispida .. .. .. ,,	4.2%
	Harpechloa falx .. .. ,,	2.1%
	Non-Gramineae—	
	Senecio species .. .. .. ,,	4.2%
	Cliffortia paucistaminea .. .. ,,	2.1%
	Helichrysum argyrophyllum .. ,,	2.1%

The basal cover increases from Plot I to Plot IV. This is explained by the fact that Plot I lies on sloping ground which was densely covered with helichrysum. The other plots were less affected in relation to their distance from the xerocline.

These results confirm observations made during a preliminary survey of the whole experimental area. The vegetal cover is still patchy owing to differences in the density of *Helichrysum argyrophyllum* at the time of burning. Localities which were densely covered with helichrysum are recovering much more slowly than those which were less affected.

Themeda triandra (rooigras) is already coming in strongly and there is no doubt that it will eventually oust the pioneer genera Aristida, Eragrostis and Sporobolus.

Its seeds prefer germinating in the shade of the pioneer grasses for it seldom colonises bare areas. Its roots are shallow and spreading. It ousts the pioneers, partly by shading and smothering them, partly by depriving them of their water supply, through its roots growing over theirs. (Bews, 1918.)

EFFECT OF FERTILISERS

On 12th December, 1949, a small unfenced plot was dressed with 4 cwts. per acre superphosphate and nitrogen in the form of ammonium nitrate at a rate equivalent to 4 cwts. per acre sulphate of ammonia. An analysis of the sward on this and an adjacent unfertilised control plot during April, 1950, gave the following results :—

Fertilised Plot		*Control Plot*	
Basal cover	17.3%	Basal cover ..	12.2%
Themeda Triandra ..	30.4%	*Themeda triandra* ..	24.4%

The species forming the basal cover in both plots are the same as those in Plots I, II, III, IV.

UNTREATED HELICHRYSUM-DOMINANT AREA—

Basal cover, 9.3 per cent—

Species :	*Helichrysum argyrophyllum* .. .. approx.	56.7%
	Themeda triandra .. .. ,,	8.1%
	Sporobolus centrifugus .. .. .. ,,	8.1%
	Eragrostis curvula .. .. .. ,,	8.1%
	Aristida galpinii .. .. ,,	5.4%
	Harpechloa falx .. .. ,,	5.4%
	Andropogon appendiculatus .. .. ,,	2.7%
	Sedge species .. .. ,,	5.4%

PROTECTED PLOT N.W., CHATHA FOREST RESERVE—

This plot was fenced off and burned in October, 1942. From available information this area was then dominated by fynbos and helichrysum—a typical macchia vegetation. Since this plot was burned in 1942 it has been protected and left ungrazed, and the following is a summary of a report dated 8th January, 1948, by 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 the fynbos was suppressed.

Third year: The plot was well grassed, the fynbos scattered but coming through and 12 inches to 18 inches high.

Fourth year: Restored to very excellent grazing; scattered fynbos 2 feet or 3 feet high.

The results of a botanical analysis (April, 1950) are as follows:—

Basal cover, 13.7 per cent—

Species:	*Themeda triandra*	approx.	58%
	Elyonurus argenteus	,,	16%
	Tristachya hispida	,,	8%
	Harpechloa falx	,,	6%
	Panicum ecklonii	,,	4%
	Aristida galpinii	,,	2%
	Non-Gramineae—		
	Sedge species	,,	4%
	Helichrysum argyrophyllum ..	,,	2%
	Helichrysum ascendens	,,	2%
	Stobaea aristosa	,,	2%

The pioneer grasses—Eragrostis and Sporobolus—are absent and Aristida appears to be diminishing steadily. The percentage of Themeda is nearly four times greater than that of its nearest competitor (*Elyonurus argenteus*). This plot, which is to remain ungrazed, should provide valuable comparative data in a few years' time with the more recently burned plots of the same type at Hogsback which are subjected to grazing at different intensity levels.

Throughout the area under revegetation at Hogsback there are several "sponges" which had been denuded of their grass cover through excessive overgrazing. According to reliable observers in the district these "sponges" 20 years ago were so wet and soft that it was not possible to traverse them on horseback. At the time of

eradicating the Helichrysum (July-August, 1949) there were no signs of any moisture in the sponges and heavy trucks could be driven over them, and streams which would normally be fed from these sources have dried up.

With a view to obtaining information on the effect of revegetation on the water-table, apparatus has been installed at various points. These points were selected by Dr. Mountain, Professor of Geology, Rhodes University College, on 29th November, 1949. On that date the adjacent sponge was quite dry and there was no water in the stream which was obviously fed from this source in the past. Indeed, according to reliable evidence this particular stream had been dry for several years. On 9th December, 1949,—ten days after the water-table points had been selected—the apparatus was installed. On this date it was not possible to walk through the sponge area without getting very wet feet unless protected by gum-boots and water was flowing in the formerly dried-up stream. This stream has not since then ceased to flow. The rainfall for November, 1949, was 4.60 inches, for November, 1948, 1947 and 1946, it was 7.11 inches, 6.07 inches and 6.22 inches respectively, but there is no record that the stream started flowing in any of these years. If it did, the flow must have ceased very quickly, as all observers agree that the stream had been dry for years previous to November, 1949.

A gauge was installed in the stream by the Irrigation Department and the flow of water measured weekly is as follows:—

Date		*Gauge Reading*	*Cusec*
14 December,	1949	.41	.28
21 ,,	,, ...	.32	.15
28 ,,	,, ...	.20	.05
2 January,	1950	.41	.28
11 ,,	,, ...	.44	.33
18 ,,	,, ...	.33	.16
25 ,,	,, ...	.32	.15
1 February	,, ...	.27	.10
9 ,,	,, ...	.24	.07
15 ,,	,, ...	.37	.22
22 ,,	,, ...	.35	.19
2 March	,, ...	.51	.48
9 ,,	,, ...	.31	.14
16 ,,	,, ...	.36	.20

Date			*Gauge Reading*	*Cusec*
22 ,,	,,	.. ..	·34	·17
29 ,,	,,	.. ..	·33	.16
5 April	,,	.. ..	·33	.16
12 ,,	,,	.. ..	.28	.11
19 ,,	,,	.. ..	.27	.10
26 ,,	,,	.. ..	.20	.05
3 May	,,	.. ..	.28	.11
11 ,,	,,	.. ..	.19	.04
17 ,,	,,	Flood over ..	·75	1.24
25 ,,	,,	.. ..	.60	·71
31 ,,	,,	.. ..	·40	.26
7 June	,,	.. ..	·33	.16
14 ,,	,,	.. ..	·29	.12
21 ,,	,,	.. ..	·24	.07
28 ,,	,,	.. ..	.22	.06
5 July	,,	.. ..	.22	.06
12 ,,	,,	.. ..	.21	.05
19 ,,	,,	.. ..	.18	.05
26 ,,	,,	.. ..	.14	.02
2 August	,,	.. ..	.15	.02
9 ,,	,,	.. ..	.25	.08
16 ,,	,,	.. ..	.25	.08
23 ,,	,,	.. ..	.23	.06
30 ,,	,,	.. ..	·59	.70
6 September	,,	.. ..	.56	.20
13 ,,	,,	.. ..	·35	.19
20 ,,	,,	.. ..	.29	.12
27 ,,	,,	.. ..	.22	.06
4 October	,,	.. ..	.24	.074
11 ,,	,,	.. ..	.15	.023
18 ,,	,,	.. ..	.18	.036
25 ,,	,,	Flood over ..	·75	1.238
1 November	,,	.. ..	·35	.189
8 ,,	,,	.. ..	·44	·332
13 ,,	,,	.. ..	·36	.202
22 ,,	,,	.. ..	.27	.099
29 ,,	,,	.. ..	.20	.047
6 December	,,	Flood over ..	·75	1.238

Total for twelve months equals 46 and one-third million gallons.

RAINFALL

The following tables give the annual rainfall at Hogsback in inches, for the years 1930-1949:—

PERIOD 1930-1939

	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939
January ..	5.36	10.38	2.54	2.10	6.20	6.21	4.63	6.04	6.57	7.46
February ..	5.98	3.05	2.22	5.93	5.44	4.47	5.82	4.6	3.68	10.70
March	10.28	3.16	3.00	5.10	4.78	4.97	5.54	9.53	3.78	8.18
April	1.43	7.02	—	4.61	1.32	7.88	1.16	1.15	3.39	1.65
May	2.92	—	2.66	.94	1.12	8.39	4.10	1.03	1.50	1.43
June	4.05	1.86	1.38	.77	1.68	1.78	.55	.29	2.61	.16
July	2.46	7.42	2.78	.13	3.75	.10	2.35	1.23	.76	3.52
August ..	7.23	1.92	.40	1.44	.09	1.82	.34	.45	2.87	2.25
September ..	4.18	4.38	9.78	1.41	1.10	1.96	3.62	4.94	2.89	6.68
October ..	6.35	4.80	5.76	1.79	1.73	3.51	8.12	3.28	5.33	6.83
November ..	3.53	5.97	6.99	6.30	2.27	6.20	10.83	7.04	9.17	4.30
December ..	7.72	5.65	3.54	3.33	5.06	5.45	2.40	10.72	7.52	4.40
TOTALS ..	61.49	55.61	41.05	33.85	34.54	52.74	49.46	50.30	50.07	57.56

Average for 10-year period 1930-1939 equals 48.66 inches.

PERIOD 1940-1949

	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
January ..	4.93	7.68	8.35	4.45	5.18	4.93	7.77	7.43	5.88	3.68
February ..	2.88	10.53	6.12	3.23	7.19	2.88	5.98	1.88	5.28	4.25
March	3.26	1.53	4.95	2.92	6.44	3.26	5.39	6.19	5.85	2.61
April	1.81	3.85	4.83	4.72	2.35	1.81	1.16	2.83	8.64	2.99
May	3.09	0.64	3.60	2.01	4.37	3.09	2.15	1.32	.56	1.01
June	1.75	2.53	.80	3.13	3.44	1.75	1.06	3.38	1.15	—
July	—	0.49	.80	.48	1.37	—	1.47	3.81	1.51	.38
August ..	.91	.25	1.47	4.78	.43	.91	1.35	.42	.31	1.62
September ..	—	1.65	3.60	3.28	3.59	—	1.42	5.09	2.32	3.42
October ..	5.39	4.19	4.96	3.49	4.83	5.39	6.26	3.30	3.55	2.73
November ..	1.66	4.69	7.68	11.36	.93	1.66	6.22	6.07	7.11	4.60
December ..	3.67	4.63	5.54	7.74	1.38	3.66	3.85	2.65	3.20	4.04
TOTALS ..	29.35	42.66	52.70	51.59	41.50	29.34	44.08	43.37	45.36	31.33

Average for 10-year period 1940-1949 equals 41.12 inches.
Average for 20-year period 1930-1949 equals 44.89 inches.

DISCUSSION OF RESULTS TO DATE (JANUARY, 1951)

The two primary objectives of the investigation—the restoration of denuded vegetation on a watershed and the stopping of surface run-off of water—have been attained.

It is clear beyond all doubt that excessive overgrazing and trampling and indiscriminate burning on the Amatoles have led to the destruction of the grass sward which dominated the area 50 years ago, and invasion of inedible helichrysum and fynbos on a large scale has taken place. It is equally clear from the work of Schonland,[1] now repeated and confirmed on a much larger scale at Hogsback, that helichrysum can be eradicated in a comparatively short time and that a more efficient water-holding grass type of vegetation can be re-established.

During the early stages of re-establishment after eradication of helichrysum, the restored grass sward is very vulnerable and could easily be destroyed again by overgrazing. The area under investigation has been lightly grazed once during the autumn of 1950. This was arranged to allow the grasses to seed and for the seed to be trodden into the ground by the grazing animals. The improvement in density of the sward was very marked and the whole area is being rested to seed again before grazing. There is another important reason for this system of management. Theron[2] has shown that losses of moisture through transpiration are much higher from young growing plants than from mature vegetation, and therefore if herbage is left ungrazed until it is mature at the end of the growing season the transpiration losses are diminshed.

But at this stage of the investigation our main objective is to reduce and, if possible, stop losses of water through surface run-off by the eradication of undesirable and ineffective vegetation and the re-establishment of a more efficient grass sward. Investigation into transpiration losses may become necessary as soon as sufficient data are available on the management of the re-established grass sward to fulfil its function of stopping all surface run-off of water.

There are strong indications that fertilisers, and particularly nitrogen, may be used with great effect to accelerate the re-establishment

[1]Schonland, S., *Ibid.*

[2]Theron, J. J. ,"Lysimeter Experiments," *Science Bulletin*, No. 288, Department of Agriculture.

of denuded vegetation. On the small unfenced fertilised plot the basal cover increased by over 40 per cent within six months of the application of the fertiliser and there was a significant increase of the dominant species (Themeda). There is no doubt that nitrogen could play an important part in the rapid restoration of denuded vegetation on vulnerable areas of a watershed and thus make an important contribution to the conservation of water. New plots, fenced and controlled, have been laid out to test the effects of lime, phosphate and varying quantities of nitrogen.

But perhaps the most significant feature of all in this investigation is the fact that after restoration of the vegetation water began to flow again in a stream which had been dry for some years. This took place within six months from the time of burning off the helichrysum followed by complete protection of the area.

Of this particular stream no one can say for certain when it dried up although several people who know the area well are emphatic that it had been dry for a number of years. The average annual rainfall of the area for the ten years 1940-49 is 41 inches and during that period it only fell below 30 inches in two years, 1945 (29.34 inches) and 1940 (29.35 inches). In 1949 when the water began flowing again the rainfall (31.33 inches) was the *third lowest* of that ten-year period and 14 *inches less than during* 1948. It cannot be said, therefore, that the re-appearance of water in the stream coincided with an increase in rainfall, since this was significantly less than for the previous year. It thus seems logical to conclude that the water now flowing in the stream (which reached a total of over 46 million gallons within 12 months) is the water—or rather its equivalent—which formerly ran off the surface because there was not sufficient vegetation to hold it and regulate its movement.

Professor Monica Wilson states (30th January, 1950):—

We have noticed for many years that the two Robinson's Falls (below Robinson's Drift) are very big immediately after rain but go down much more quickly than any of the other falls on the Hogsback. The first thing I noticed on our journey up on December 6th was that Robinson's Falls were conspicuous though there had not been rain quite recently, and they have kept up all summer even after a dry week at the end of this month. When I walked up the old road in mid-December I found the Drift larger than I ever remember it, and a stream which I had never seen before flowing out of a sponge on the commonage and across the old road from South to North, between Robinson's Drift and the Tyumie Drift. The grass on the commonage is longer and thicker than I have ever seen it.

I have walked or ridden on the commonage almost every summer since 1920, and remember it vividly from that time.

This investigation has already shown that serious losses of water, and soil carried away in the water, are taking place over large areas of denuded vegetation through surface run-off. The conservation of water begins by preventing rain from running off the surface of the land where it falls. This is most easily, most economically and most effectively achieved by vegetation properly controlled. Losses of water through surface run-off—and incidentally the amount of soil carried away in the water—depend on the nature of the rainfall, slope of the land and density of the vegetation.

Since the watersheds of the country are the regions of highest rainfall and steepest slopes it becomes imperative to restore where denuded, and preserve afterwards a sufficiently dense type of vegetation to prevent the rainwater from pouring in torrents down the slopes, eroding lower-lying land and carrying away valuable top-soil to the rivers and the sea. Over vast areas of the watersheds of the country the vegetation has been severely damaged through gross mismanagement over a long period, and irreparable losses of soil and water as a consequence are now causing grave concern to those who have the welfare of the country at heart and who fear continued neglect of these vital and vulnerable areas.

The need for further and continuous study of watershed problems is urgent. It has been almost completely neglected in the past, and information essential for the effective control of these vital areas is sadly lacking. We do not know nearly enough about the relative suitability of different types of vegetation at varying altitudes or the effect of different soil conditions. However effective a well-managed grass sward may be in preventing surface run-off of water and erosion of soil, there are many areas of the watersheds too steep for grazing and without animals or fire or both, reversion to natural forest is probable and may be highly beneficial.

The following observations on reversion of grassland to forest in the Hogsback area by Professor Monica Wilson (23rd January, 1951) are of special interest :—

Most of "Hunterstoun" has not been burned since 1916. At that time it was short grassveld with many clumps of Watsonia in it similar to the unplanted part of Mr. Summerton's bluff this season (1950-51). Burning was discontinued in 1916 and the land was never heavily stocked. Today the larger camp is thick with self-sown pines (mainly *Pinus pinaster*) and there is a heavy undergrowth over the greater part of it, of Erica, Cliffortia and bramble (Rubus). Along the stream, and in another section away from water, black wattles (*Acacia mollissima*) have grown to a great size. But in the midst of

all this growth indigenous forest trees, notably yellow-wood (Podocarpus), Celtis, *Rapanea melanophloeos*, Kiggelaria and Pittosporum are coming on fast. They come up through the bramble and Erica, and, after a time, *under pine and blackwattle*. I was very much surprised when I saw, for the first time, yellow-wood under blackwattle, but there is no doubt that it is flourishing in many places on "Hunterstoun" under wattle cover. Old wattles have almost no wattle seedlings under them, the shade being dense, and it is here that yellow-wood comes most readily, but it is also visible among wattle saplings in some places, I think where there previously have been old wattle trees giving dense shade.

The yellow-wood appears most quickly in deep black soil on the fringes of existing indigenous forest, but it is not confined to these areas. Seedlings appear a mile or more from the nearest yellow-wood tree, and on relatively dry, red soil. As you know, of course, yellow-wood does not flourish without shade, and three of the commonest indigenous covers for the seedlings are bramble, *Halleria elliptica* and Buddleja.

This self-seeding of yellow-wood is obvious not only on "Hunterstoun," but through the Government plantations, far up the western slopes of Hogsback Mountain, and north-west at least as far as Innisfree. In the plantations most of the young yellow-woods coming on are destroyed when the pines are felled. As their rate of growth is so much slower than that of pines, and they only start after the pines give them shade, they rarely have a chance to grow into sizable trees, and no regard is paid to saplings when plantations are felled.

The process of reversion to indigenous forest is slow. The yellow-woods do not seem to appear until there has been shade for a good many years, and if the ground is disturbed they do not come at all. Our maximum rate of growth on "Hunterstoun" for self-sown yellow-wood is approximately twenty feet in thirty-five years protection. Reversion to forest turns on protection from fire, no heavy stocking and, I think, no felling—certainly no systematic clearing—of the trees which have afforded cover. If large trees are felled and logs pulled out the young yellow-woods are mostly destroyed, but if the cover trees are left to decay and fall themselves without men and beasts trampling the place, the yellow-woods survive. This also has been evident on "Hunterstoun." Therefore during the period of reversion to forest there can be no direct economic return from the land at all. The process has another serious difficulty: the tangle of Erica, bramble and other shrubs which shade the young trees is highly inflammable, and land which is left to revert to forest commonly regarded as a danger to the neighbourhood. Presumably it is because growth of this sort is so inflammable that the Forestry Department hoes its fire-belts close up to well-grown forest and so prevents the indigenous forest gradually spreading out as it would otherwise do, and as Sim recommended long ago that it should be allowed to do.

Nevertheless, in spite of these difficulties, it may well be profitable to the country as a whole to protect steep slopes on watersheds and allow them to revert to indigenous forest. During dry weather the earth in indigenous forest appears to be far damper than that in plantations or on grass-land.

There are a number of problems relating to the re-establishment of forest, which should, I think, be investigated. How long does the process take and what are the optimum conditions for it? Here I have only been able to make suggestions based on piecemeal observations. To what altitude will yellow-wood grow on the Amatole

Mountains, and is the limit really altitude or type of soil ? It is flourishing up to 5,000 feet on the Hogsback but I have seen it up to 8,000 feet in Tanganyika. Will yellow-wood come under dense Cliffortia or not ? Would it be possible to establish it on the eastern slopes of the Hogsback too steep for grazing, either by planting seeds under Cliffortia, or by sowing Halleria and later yellow-wood ? Incidentally, the common idea that it is impossible to transplant yellow-wood seedlings is demonstrably false.

Since yellow-wood is much longer lived than pine or blackwattle, and yellow-wood seedlings come up in dense shade whereas pine and blackwattle seedlings do not, the presumption is that, given time, yellow-wood will oust the pine and wattle, but this has yet to be proved by a long-term experiment. The largest yellow-woods to have come up under wattle on " Hunterstoun " are only ten to twenty feet high, and wattle is still coming up round them. In a report by E. A. Schelpe of the Oxford University Expedition to Kenya, which appeared in the *The Listener* for January 19th, 1950, it is stated that . . . " Fire devastates large areas on Mount Kenya from time to time . . . . The devastated area is first colonised by heathers which grow up to a height of six feet. On the floor of this scrub the young cedars develop and give rise to a pure stand of cedar saplings. These saplings cast a dense shade below them which shades out the heathers beneath."

Since the seedlings of the cedar are light-demanding no further development of very young cedars occurs beneath the older saplings. However, yellow-wood seedlings require deep shade for their early development, as I mentioned above. Consequently a mixed forest of cedar and yellow-wood trees develops. Dense shade is still being cast on the ground at this stage, and, although more yellow-wood seedlings continue to develop in each successive year, cedar seedlings are unable to do so. So it is only a matter of time before the old cedar trees die out, leaving an almost pure yellow-wood forest."

I think that the same process is going on on the Hogsback with exotic pines and blackwattle (as well as many indigenous trees) in place of the Mlanje cedar, but exact and long-term observation will be necessary to demonstrate this.

From such evidence as we have, however, I suggest that the re-establishment of indigenous forest on grassland, and probably even on wattle-ridden land, is practicable on the Hogsback, and that the advantages of inducing such forest on the steepest mountain slopes be considered seriously.

I shall be glad to show the sceptical the yellow-woods growing under black-wattle and pine at any time when I am on the Hogsback.

Although much more research work is necessary before the vegetation of the watersheds can be restored and maintained at their most effective levels to conserve water and soil, there are sufficient data available from " Hogsback " to begin restorative operation on the vulnerable and vital areas on a big scale. We know that complete control of the movements of grazing animals is essential—their retention on an area when defoliation is beneficial and their exclusion when grazing or trampling would be detrimental to the vegetation.

Since there are only three methods of controlling movements of animals—fencing, herding and tethering—and the latter is impracticable on watersheds, the choice lies between fencing or herding or a combination of the two. Herding has the advantage over fencing in that it can be put into operation with no more delay than is necessary to secure the rangers and mark the boundary points. The importance of the time factor needs no emphasis in watershed reclamation. The success of herding depends on the efficiency of the rangers and the co-operation of the stock owners. For obvious reasons, however, many hundreds of miles will have to be fenced and for this vast quantities of fencing material will be required.

Much more information, essential for the effective control of the watersheds once the initial stages of vegetation restoration and animal control have been reached, is still required. Although we know that the major function of a watershed vegetation is to conserve water and secure the soil against erosion we do not know the most suitable types for different watersheds or different areas of the same watershed. One can visualise conditions where it would be a losing battle to fight for the maintenance of a grass type of vegetation where the climax was clearly forest.

We do not know how a watershed vegetation should be managed to maintain it at its peak for the conservation of soil and water, nor do we know how " sponges " or seepage areas should be managed. The essential data are not yet available because there has not yet been sufficient work done on watershed problems to provide the information. Has anyone ever known of a " sponge " being grazed or trampled out *before* the adjoining vegetation had been destroyed or at least severely denuded ? My own observations indicate that the destruction of a " sponge " does *not* precede but *follows* the destruction of the vegetation of which it forms a part and I have not yet found any denuded trodden out " sponges " on the Amatoles where the adjoining and related vegetation is in good condition.

How should those " sponges " be treated in a watershed grass type of vegetation ? Should they be treated as special areas, fenced off and left ungrazed for all time, or should they be returned after restoration to the grazing areas of which originally they formed a part ? These are vital questions to which we do not yet know the answers, and the answers must be found if the watersheds of the country are to fulfil their functions effectively in the conservation of water.

This investigation, incomplete as it is, quite clearly points the way towards a simple and relatively inexpensive method of halting the losses of water and soil on a watershed and it may help to clarify a certain confusion of thought on the subject at the present time. Since the denudation has been caused by excessive overgrazing through lack of control of animals often in excess of the vegetation to sustain them, some prominence has been given to the view that all farmers, European and Native, and all livestock should be removed from the watersheds and that these regions should become unstocked National Reserves.

This is analogous to suggesting that the remedy for soil erosion is to *stop all farming*.

It is significant that while this exploratory investigation has resulted in reclamation of a large area to the extent of restoring denuded vegetation and conserving water which formerly vanished in surface run-off, it has been carried out without any disturbance of people or livestock. The grazing rights of the Natives concerned have been respected but strict control has been imposed by the Native Commissioner of the district (Alice), Mr. T. C. Cordingley, in the administration of these rights. Grazing rights have been interpreted as rights to graze when such grazing would not impair the vegetation or endanger water supplies. This strict administrative control has resulted in the Natives concerned having more and better grazing from the area than they ever had before. There was no culling of stock.

It is not suggested, of course, that all the watersheds of the country could be rehabilitated without any disturbance of people or reduction of livestock. But the Hogsback investigation is suggestive of possibilities which are well worth exploring. The cause of veld denudation is commonly assumed to be due to overstocking but no one knows the relative contributions to this through excessive numbers of stock or failure to exercise proper control over the movements of the animals. There are no data available at different levels of stocking under controlled movement of the animals so far as the Native Reserves are concerned. But it does not require much imagination to realise that vegetation on one area may be maintained in excellent condition by proper control of animals whereas on another equal area at the same rate of stocking the vegetation may be denuded or ruined through lack of animal control.

This does not, of course, imply that there is no overstocking on watershed regions. The vegetation over large areas is so badly denuded that it is unfit for any grazing until it has been restored by resting. But since these areas are generally used in conjunction with veld at lower altitudes the possibilities of their reclamation immediately becomes apparent. As was the case at Hogsback where the watershed grazing had vanished through destruction of the grass sward, animals lose nothing by being denied access to an area without feed to sustain them. The problem then is whether or not the lower lying veld can maintain the stock without reducing the numbers until recovery of the watershed vegetation. In the Hogsback investigation it was possible to do so.

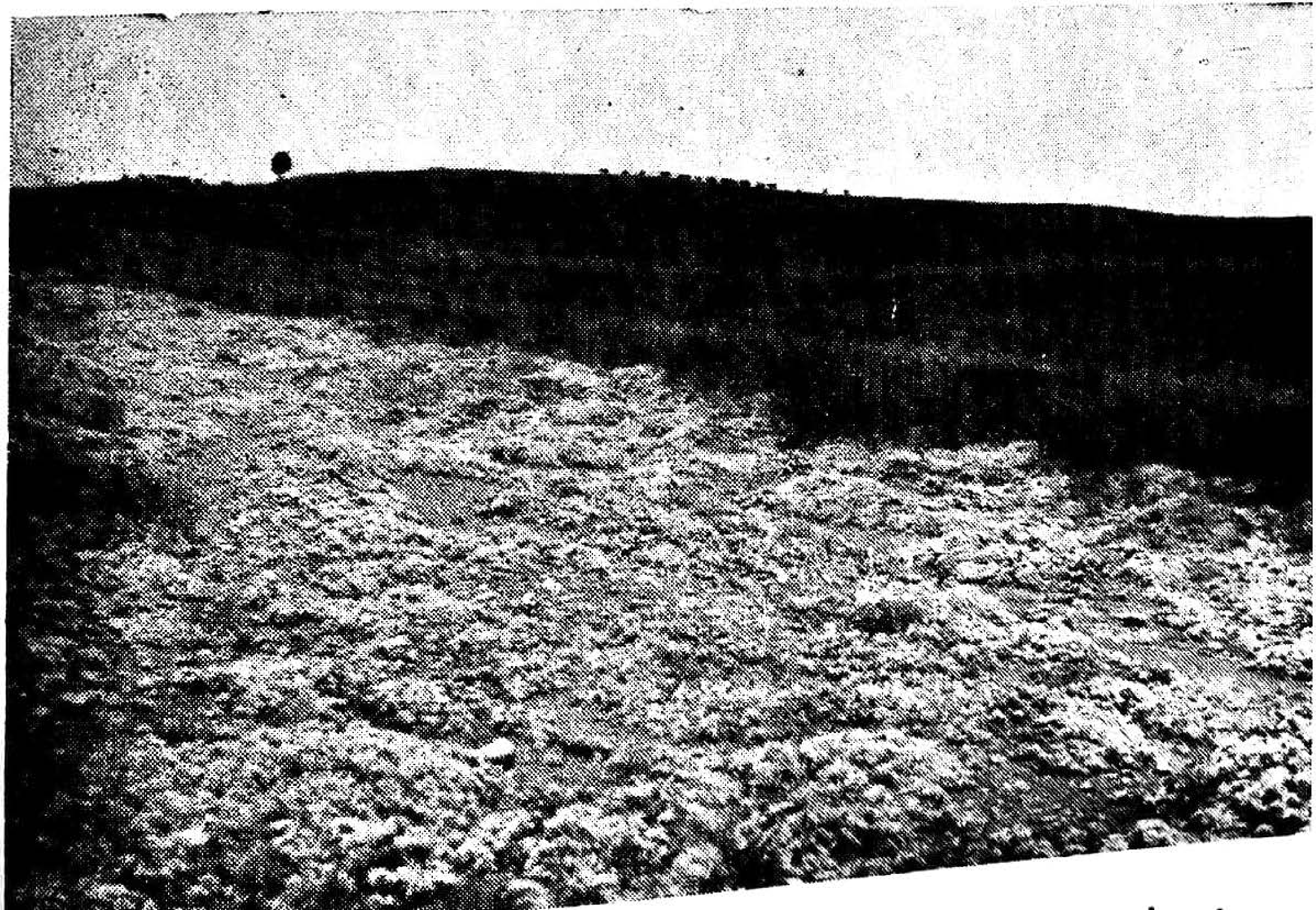
The preservation and maintenance of the vegetation on a watershed to perform its function of holding the soil and the water is no more than an obligation on the part of those who are privileged to utilise these high rainfall and potentially productive regions. This is no more than compliance with the simple laws of good husbandry, and any legislation necessary for its enforcement would be irksome only to those who cannot or will not exercise proper control of the movements of their grazing animals.

No one who has stood by a river mouth watching the muddy, silt-laden water discharged into the sea can possibly overrate the achievements of man. For here is a striking example of man's incapacity to use and preserve two of the most vital elements for his own survival; soil and water. And no one who has studied the South African climate with its intermittent droughts and floods can fail to realise that both agriculture and industry are doomed to failure if we depend entirely for water supplies on the rain which falls annually without adequate measures for its conservation and the storage of the surplus for future use.

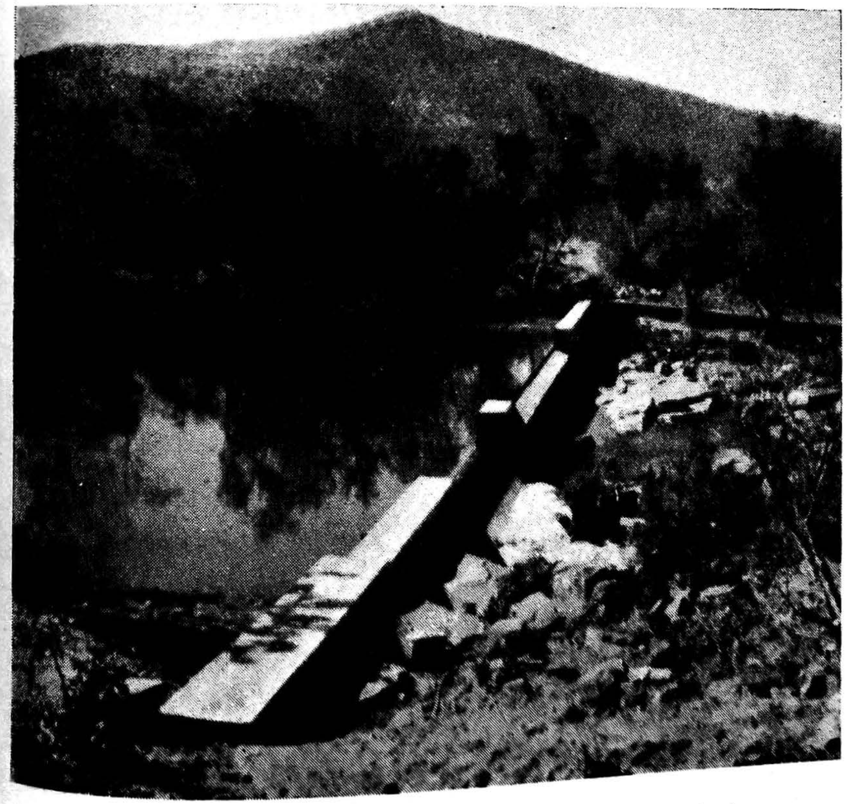
Although the investigation described in this paper covers a period of less than two years and the importance of the subject calls for much further study, the results to date show quite clearly that controlled vegetation plays a vital role in the conservation of water on high rainfall mountain regions. And it is equally clear that on these same regions devastating losses of soil and water are inevitable if the vegetation is not properly cared for and preserved.

Invasion of Helichrysum on Amatole Mountains. Left of fence, untreated. Right of fence, after burning.

Another view of the restored grass sward in foreground with untreated Helichrysum area beyond fence.



Measuring the flow of water from restored "sponge" into stream.

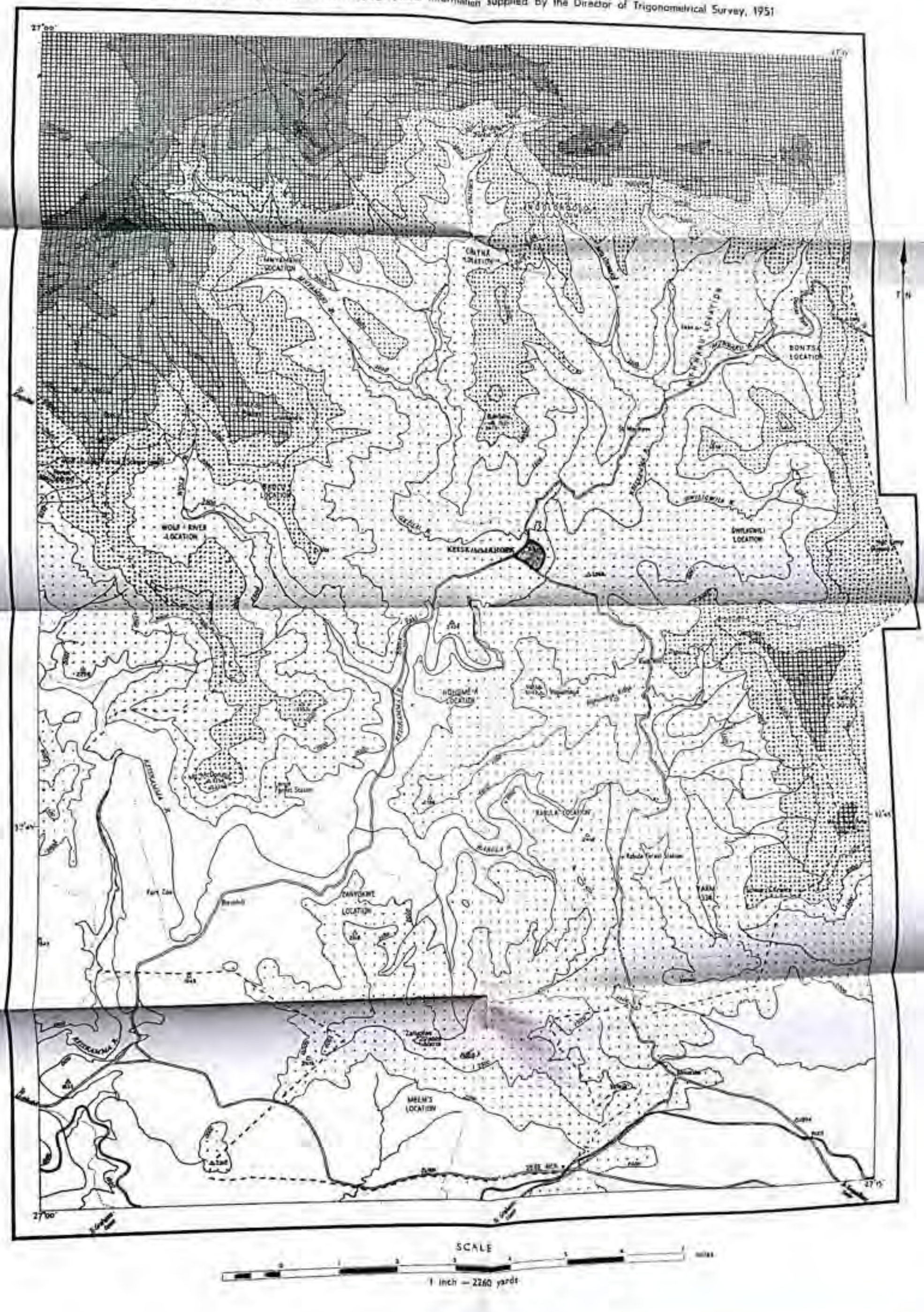


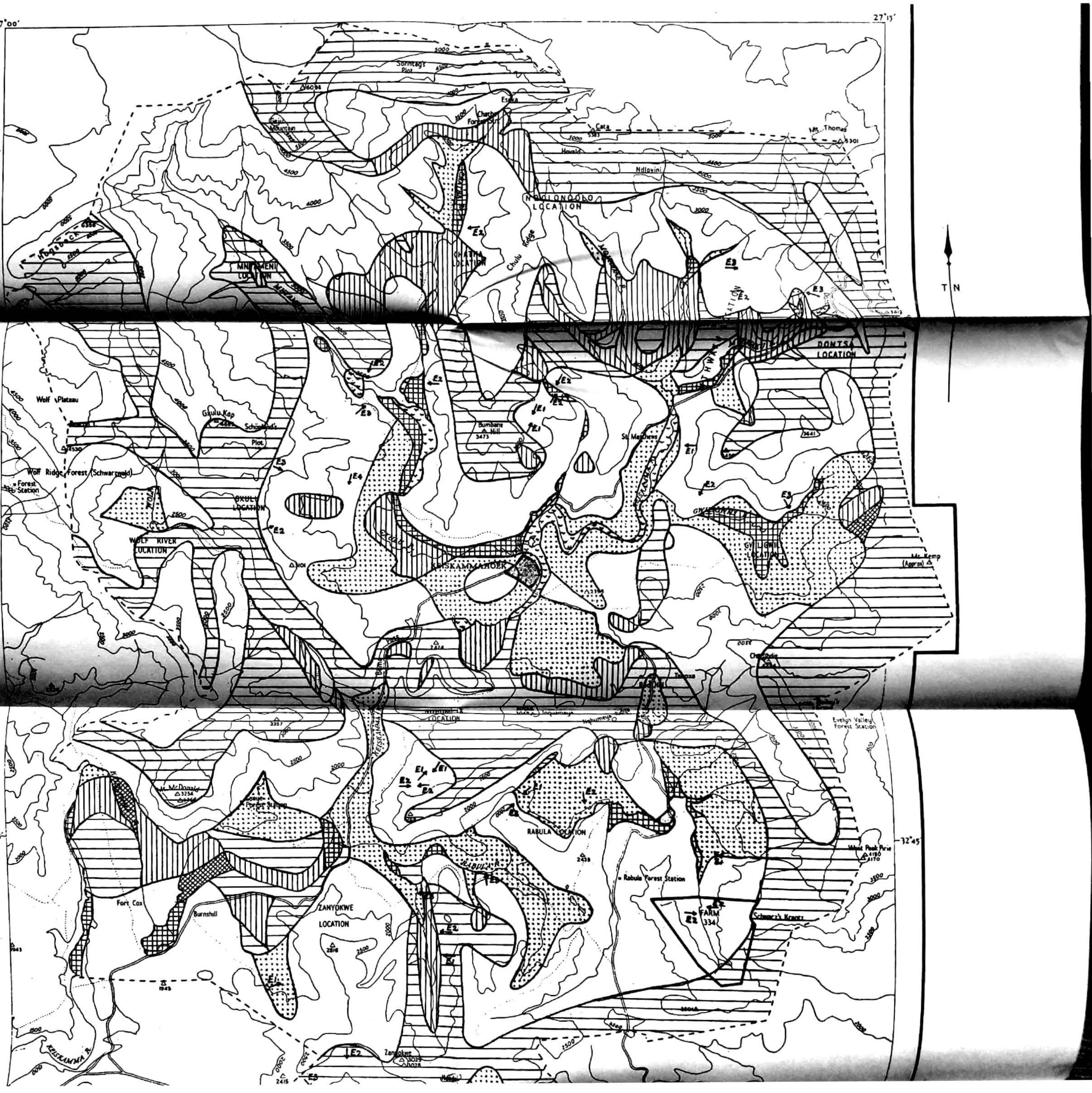
Weir on Keiskamma River to measure stream flow (side view).

Reappearance of water in formerly denuded " sponge " after restoration of the vegetation.

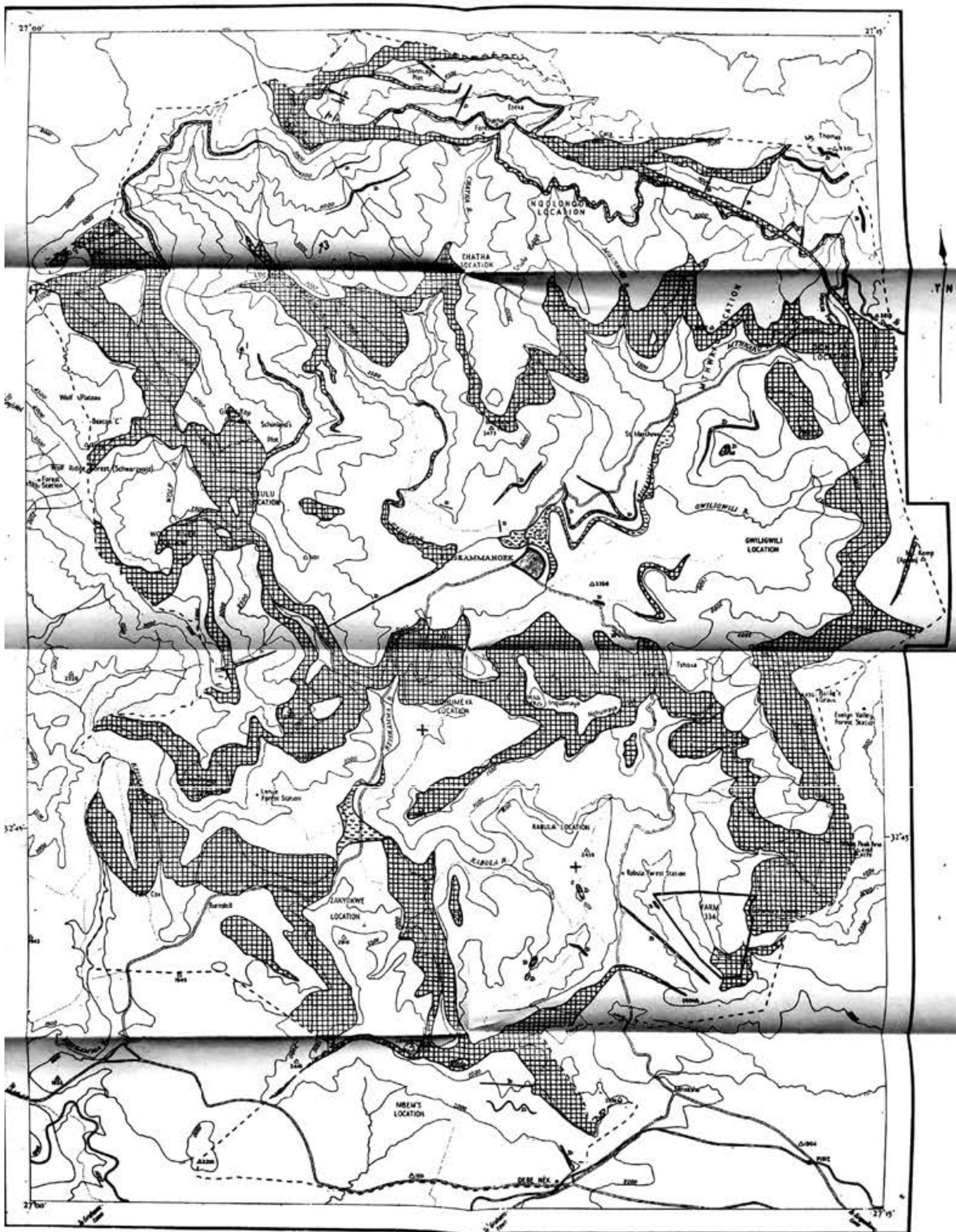
MAP OF KEISKAMMAHOEK

Drawn by Mr R. Story and based on Topographical Information supplied by the Director of Trigonometrical Survey, 1951




27°00'
27°15'
32°45'
T N
Sonntag's Plot
Mt. Thomas
Ndlovini
NDLOLONOOLO LOCATION
CHATHA LOCATION
Chulu Ridge
MNYAMENI LOCATION
DONTSA LOCATION
Wolf Plateau
Gxulu Kop
Schonlands Plot
Wolf Ridge Forest (Schwarzwald)
Forest Station
WOLF RIVER LOCATION
GXULU LOCATION
Bumbane Hill
St Matthews
KEISKAMMAHOEK
GXULU LOCATION
Mt. Kemp (Approx)
Evelyn Valley Forest Station
Mt. McDonald
RABULA LOCATION
Rabula Forest Station
West Peak Pirie
ZANYOKWE LOCATION
Fort Cox
Burnshill
FARM 334
Schwarz's Kranz
Zanyokwe
KEISKAMMA R.

GEOLOGICAL MAP OF KEISKAMMAHOEK



KEY

Alluvium

Karroo Dolerite

Lower Beaufort Series

SCALE

0 1 2 3 4 5 6 7 miles

1 Inch = 2260 yards