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SURVEY OF THE NORTHERN RANGELANDS

S O M A L I D E M O C R A T I C R E P U B L I C

AN ECOLOGICAL CLASSIFICATION OF THE VEGETATION OF THE BOSASO REGION

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C O N T E N T S

		Page
1.	INTRODUCTION	1
1.1	The Present Account	1
1.2	Previous Work	2
2.	CLIMATE	3
3.	GEOLOGY AND GEOMORPHOLOGY	5
3.1	Coastal Plain	5
3.2	The Mountains	6
3.3	Daror Depression	6
3.4	Shol-Carcar Plateau	6
3.5	Nogal Valley	6
3.6	Lava Areas	7
4.	SOILS	8
5.	COASTAL AREAS	10
5.1	Raised Coral Reefs	11
5.2	Conglomerate Plains with Overlying Marine Sand	14
5.3	Silty Coastal Plains	15
5.4	Ancient Aeolian Sand Remnants	15
5.5	Estuaries and Inlets	15
5.6	Hafun Peninsula	16
5.7	Nogal Gorge at Eil	17
6.	SUB-COASTAL ZONE	20
6.1	General Description	20
6.2	Eastern Ahl Medo	21
6.3	Carin Gap	22
6.4	Daror Depression	24
6.5	Eastern Lowlands	26
6.6	Stone-Mantle Areas	28
6.7	Watercourse Vegetation	30
7.	ACACIA BUSSEI OPEN WOODLAND	31
8.	EVERGREEN SCRUB	33
9.	JUNIPERUS FOREST	34
10.	HAUD-TYPE MIXED BUSH	35

Page

11. GYPSEOUS AREAS 37

11.1 The Nogal 37
11.2 Meleden Area 38
11.3 Gardo Area 39

12 DISCUSSION 40

LIST OF TABLES:

Table 1. Mean Annual Rainfall 3

Table 2. Analysis of Soil Samples 9

REFERENCES 42

APPENDIX I 45

Fig. 1. Outline map of the Bosaso Region showing the routes covered during reconnaissance trips in 1959 and 1970 . 47

Fig. 2. Generalised map of the vegetation zones of the Bosaso Region 49

Fig. 3. Rainfall map of the Bosaso Region 51

Fig. 4. Map presenting the geographical distribution of the different ecological successions in the Bosaso Region. 53

APPENDIX II 55

Plate 1. A relict of the former coastal plain on the north coast near the tip of the Somali peninsula 57

Plate 2. An area of dense Acacia edgeworthii and Solerostephane adenophora on the coastal plain near Bargal 57

Plate 3. The estuary of Tug Galwein. The vegetation on the highly saline banks is almost pure Tamarix nilotica. Wind-blown sand on the slopes supports Salvadora persica 59

Plate 4. Dense cushion-like wind-resistant plants on the top of the limestone cliffs overlooking the Nogal Valley at Eil. The dark-coloured plants growing in the crack are Pulicaria sp. 59

		Page
Plate 5.	Small stony tug in the Carin gap with an intermittent line of mature *Mimusops angel*	61
Plate 6.	A wide section of Tug Yalho in the Carin gap with numerous large *Conocarpus lancifolius*	61
Plate 7.	The oasis of Carin seen from the edge of the Carin gap	63
Plate 8.	A shallow depression of fine colluvial soil derived from the surrounding stone mantles. In the central wettest area traces of *Chrysopogon aucheri* remain...	63
Plate 9.	Old tracks colonised by *Dactyloctenium robecchii* in a bare section of the Eastern Lowlands	65
Plate 10.	*Acacia ankokib*, a common species in the tugs in the north-east part of the region	65
Plate 11.	*Acacia bussei* open woodland. A few trees remain in isolated patches of *Andropogon kelleri*. Most of the plateau is now completely bare	67
Plate 12.	Severe erosion produced by prolonged over-grazing on colluvial valley soils within the zone of *Acacia bussei* open woodland.....	67

1. INTRODUCTION

1.1 THE PRESENT ACCOUNT

The UNDP/FAO Northern Somali Republic Rangelands Project embraces the NW and NE Regions together with the Bosaso Region. Previous work (Hemming, 1966) described the vegetation of the NW and NE Regions 1/. The object of this account is to extend that study eastwards to incorporate the tip of the Somali peninsula, formerly known as the Mijertein and now called the Bosaso Region.

The present report is based on field work undertaken when the author was Consultant Ecologist to the project in 1970 and also on field work in 1959 undertaken as part of the systematic ecological investigation of the vast area covered by migrating and breeding swarms of the Desert Locust. The routes covered during reconnaissance trips in 1959 and 1970 are indicated in Figure 1.

The ecological zones described are the same as those in Hemming (1966) in order to permit direct comparison, but in the Bosaso Region the ecological zonation is not dominated by an east-west scarp. The result of this break in the scarp and the presence of the Indian Ocean to the east is to produce increasing vegetation with altitude principally from east to west instead of from north to south. Except for the hill masses of Ahl Meskat and Ahl Bari, most of the region lies below the Acacia bussei zone, and much of the north and east coasts consists of steep cliffs into the sea so that true coastal plains are poorly represented, whereas the equivalent of the sub-coastal zone is very extensive. In this account the name 'sub-coastal zone' is preserved because of the botanical similarities with that zone in the NW and NE Regions. In this region they are, however, found far from the sea, whereas further west they occur principally at the base of the main scarp.

This account is written as an extension to Hemming (1966) and should be read in conjunction with it. The regions naturally have much in common and more attention has therefore been paid to the differences. Such subjects as the degradation of the Acacia bussei open woodland, which are dealt with extensively by Hemming (loc. cit.) here receive less attention.

The basic ecological zonation within the Bosaso Region is indicated in Fig. 2. In order to ensure that the zones join up with similar zones in the eastern part of the area previously mapped (Hemming, 1966), the present map has been extended westwards to 48°E.

This study has brought to light several inconsistencies, and some changes have had to be made particularly with respect to the areas formerly marked as Acacia bussei open woodland, some of which have now been re-mapped as Gypseous areas.

In November 1970 the ecologist was able to cross the Ahl Medo from south to north along a new road which reaches the coast at Las-Khoreh. During the descent of the escarpment notes of the ecological zones were made. As a result of these observations the zonation of the eastern Ahl Medo has been redrawn to include Juniperus forest at the top and to exclude the Acacia bussei open woodland at the bottom of the scarp between the Acacia etbaica open woodland and the Sub-coastal zone.

1/ The NW and NE Regions today comprise the area described as the Northern Region by Hemming (1966)

Thanks are extended to Mr. Ahmed Haji Noor, range specialist to the project who accompanied the ecologist on the field trips, helped him to obtain much information which would otherwise have been unobtainable and assisted in the preparation of the maps which accompany this report.

1.2 PREVIOUS WORK

In 1953 and 1957 expeditions were made into the Ahl Meskat mountains by Prof. G. Scortecci, whose illustrated accounts of these expeditions (Scortecci, 1953-55, 1958, 1959) provide the present author's source of information on these areas which can only be investigated by foot expeditions; he was unable to undertake such journeys in the time available.

Geological investigation of the area has also been carried out and maps have been compiled by Al Azzaroli and G. Merla (AGIP, 1957 and Azzaroli, 1957).

In connection with the publication of the vegetation map of Africa south of the Tropic of Cancer by l'Association pour l'Etude Taxonomique de la Flore d'Afrique Tropicale (BUP, 1959), an ecological account of the Somali-Ethiopian area based upon physiognomic types has been given by Prof. Pichi-Sermolli (1957).

2. CLIMATE

A comprehensive account of the climate of the Bosaso Region cannot be given owing to the paucity of meteorological stations.

The main weather pattern is determined by the NE and SW monsoons. The exact direction of the 'South-west' monsoon depends upon both latitude and local topography. The NE monsoon, which brings the "Der" rains and the cooler weather, begins to blow during October and continues until April when the south-wester sets in after a calmer period of light irregular winds lasting a week or two. The main "Gu" rains occur during the early part of the SW monsoon, which continues to blow strongly until about September. This season is called the "Kharif" and is characterised by both strong winds and high temperatures.

In the Somali peninsula rainfall decreases towards the east where prolonged droughts, lasting a year or more, are not uncommon. In general the east coast gets more rain than the north coast and rainfall increases southwards down the east coast.

Rainfall records are available for 11 stations and the information is summarised in Table 1.

Table 1

MEAN ANNUAL RAINFALL (mm)

	Mean	No. of years of records	Probable limits (95%) Maximum	Minimum
North coast:				
Qau (Bender Zaida)	28	1	105	0
Bosaso (Bender Cassim)	17	10	75	0
Candala	39	5	125	0
Alula	24	4	100	0
C. Guardafui	89	6	210	30
East coast:				
Hordio	123	1	250	45
Hafun (Dante)	48	2	140	5
Eil	140	7	290	50
Inland stations:				
Scusciuban	60	7	160	10
Gardo	111	12	230	30
Garoe	100	2	225	30

As is typical of areas of low rainfall, there is great variation from year to year, and Table 1 shows the range within which the actual rainfall is likely to occur in 19 out of 20 years. This has been derived from Griffiths & Hemming (1963).

The rainfall map (Fig. 3) is based upon the limited rainfall data given in Table 1, and the positions of the isohyets between the rainfall stations have been estimated by considering the altitude and vegetation in the manner described by Griffiths & Hemming (1963), and by comparing this area with the NW and NE Regions, where the cover of rainfall stations is somewhat closer. The evidence for the 750 mm isohyet on the peaks of Ahl Meskat is that similar forest at the same altitude further west at Dalch receives a mean annual rainfall of 830 mm and there is strong field evidence that there is a general reduction in rainfall eastwards along the Somali peninsula.

The relationship between increase in rainfall and increase of altitude for the Bosaso Region cannot be calculated owing to inadequate records. An approximation may, however, be obtained by comparison with Erigavo in the north-east region. Erigavo situated at 1753 m receives a mean annual rainfall of 336.6 mm and Dalch at 2149 m receives 829.9 mm. These figures give an increase in rainfall of 125 mm/100 m, but are somewhat distorted because stations such a Erigavo, that lie just south of the main scarp, are in some kind of rain shadow and increases of rainfall such as 125mm/100m will only be applicable at higher altitudes in equally exposed sites. These figures fall within the range of variation found over a wide area of the eastern decline of Kenya (Trapnell & Griffiths, 1960).

At altitudes above about 1500 m, mists are particularly frequent, especially upon sea-facing slopes. In 1970 very heavy morning mists and dew were encountered at several places not directly exposed to the sea and at altitudes as low as 210 m.

In general, the narrow coastal belt along the north coast and the wider lowland areas on the east coast of the Bosaso Region receive a mean annual rainfall less than 100-150 mm with high air temperatures, high humidity and a low diurnal variation in temperature. The extensive central inland plateau areas above 400 m and below approximately 915 m probably receive between 150 and 200 mm of rain with somewhat lower air temperatures and humidity and a higher diurnal variation in temperature. In the northern mountain areas, above 915 m, rainfall increases rapidly with altitude up to a probable maximum of 750 mm at about 2140 m, with low temperatures including occasional frosts, frequent mists and a high diurnal range of temperature.

Temperature records are available for three stations: Bosaso (north coast), Eil (east coast) and Sousciuban (inland).

At Bosaso the average mean monthly maximum for 1944-45 was 40°C in July and August, with a mean monthly minimum of 21.1°C for November, the coldest month. The average mean diurnal range is 7.8°C. At Eil the average mean monthly maximum for Italian records prior to 1940, was 36.1°C for May, while the average mean monthly minimum for December and January was 21.1°C, with an average diurnal range of 10°C.

At Sousciuban in 1944 the average mean monthly maximum was 38.3°C for May and June, while the average mean monthly minimum was 17.2°C for January and February with an average diurnal range of 12.8°C (Hunt, 1951). A larger diurnal range for an inland station is usual; and at inland stations at a high altitude a much larger diurnal range may be expected, and 22-28°C is not unknown.

3. GEOLOGY AND GEOMORPHOLOGY

The Basaso Region is more complicated that the NW and NE Regions which can be divided into two main physiographic regions consisting of coastal lowlands and an uplifted plateau separated by the E-W scarp. In the Bosaso Region there is no continuous E-W scarp because the hills comprise two well separated hillmasses, the Ahl Meskat and Ahl Bari, but there is a fault scarp along their southern edges. The hills are thus separated from the plateau further south by the Daror depression. The plateau dips gradually south-east towards the Indian Ocean and there is thus no clear delimitation between the plateau and the coastal lowlands comprising sub-coastal areas and the small amounts of tru coastal plains.

3.1 COASTAL PLAIN

The coastal plain extends along the whole of the NW and NE Regions but only 35 km into the Bosaso Region. Further to the east the slopes of the Ahl Meskat mountains descend more or less directly into the sea and there is no coastal plain until Candala (49.52 E), where it is narrow and extends only about 6.5 km to the east before the mountains again descend into the sea. The largest stretch of coastal plain extends from Durbo (11.37 N, 50.20 E) to Bereda (11.52 N, 51.03 E), a distance of 96 km. At Durbo the plain is very narrow but it gets wider further to the north-east reaching a width of about 16 km. At Bereda the coastal plain is again cut by the north-east tip of the Ahl Bari.

The extreme north-east tip of the Somali peninsula is 200 m above the sea, but forms part of a sandy triangle which has parts of both its northern and its eastern sides at sea level. In some areas where the hills reach the sea there are, however, small relicts indicating the presence of a former coastal plain (Plate 1).

On the east coast there are two major areas of coastal plain at Barbal (11.17 N) and Hordio (10.34 N). These two sections are only separated by Mt. Holim at Ras Binnah. The total length of these plains from north to south is about 90 km.

To the south of the Hafun peninsula existing maps indicate a narrow coastal plain, but it was not possible to visit this area as time did not permit an expedition on foot.

Further south there are only small recesses in the cliffs with short beaches at Bender Beila (9.30 N) and Eil (7.59 N) and no real coastal plains.

The coastal plains consist largely of Pleistocene raised coral reefs. Where the plain is narrow, stony pediment material and alluvial gravel comonly overlie the coral. In the Carin gap the coastal plain is covered with gravel derived from Miocene conglomerates.

Marine sand is also common on the coastal plains and is found in two forms, the first being a flat mantle of compact sand now more or less stabilised against wind erosion. The second form is loose mobile windblown sand.

Parts of the coastal plain at Hordie consist of a thin layer of limestone containing many bivalves, suggesting a former shallow marine deposit.

3.2 THE MOUNTAINS

The northern part of the Bosaso Region consists mainly of three mountain blocks. The Ahl Medo range, extending from the NE Region in the west, has only its eastern end in the Bosaso Region. The main mountain block is the Ahl Meskat which rises to 2200 m. The third mountain block is the Ahl Bari which rises to 1400 m and occupies the north-eastern part of the region.

These mountains are the products of two series of faults, the Gulf of Aden and Red Sea trends. The massive fault scarp above the south side of the Ahl Meskat is particularly clear. The main series of faults of the Red Sea trend occurred during the Upper Eocene - Oligocene, and those of the Gulf of Aden during the early Miocene (Somaliland Oil Exploration Company, 1954).

These mountains are mainly composed of horizontal beds of Cretaceous and Eocene limestone, and the characteristic landscape is provided by table-topped hills descending in giant steps to the deeply incised river beds.

3.3 DAROR DEPRESSION

Along the south side of the Ahl Meskat there is an abrupt fault scarp running WNW - ESE. To the south lies the Daror depression between the altitudes of 430 and 610 m. This area has a complex geological history for it was submerged during the Miocene by a great lagoonal inlet, which, for a time, also included the Carin gap (Azzaroli, 1957). Much of Daror and the Carin gap is now covered with conglomerates ("Upper conglomerates" of Azzaroli, and "Upper Daban Series" of English authors further west). These beds are the products of erosion over a considerable period of geological time.

The floor of the northern side of the Daror depression is covered near the hills with an assortment of gravels, and elsewhere with deposits of finer alluvium and wind-blown sand.

The depression dips to the east where it joins deeply dissected lowlying rocky country.

3.4 SHOL-CARCAR PLATEAU

The Shol-Carcar plateau forms the main central upland mass of the Bosaso Region. The carcar mountains comprise the northern edge of the plateau and consist of the dissected remnants of its uplifted northern edge. Their summits reach a little over 930 m and form the highest part of the Shol-Carcar area.

This area is composed of Middle to Upper Eocene limestone of the Carcar series. The plateau area lies mainly between 600 and 900 m, dipping gradually to the south-east, where, below about 410 m, it becomes rough, stony and dissected. The Shol plateau is extensive, covering at least 95 km from north to south and 80 km from east to west. The whole area is generally flat with scattered small table-topped hillocks.

3.5 NOGAL VALLEY

The Nogal valley runs approximately east-south-east to the south of the Shol-Carcar plateau area. The Nogal represents an ancient drainage line formed by a fault of the Red Sea trend (Somaliland Oil Exploration Company, 1954), and may be regarded as the final dying-out of the main trough faulting of the Red Sea (Macfadyen, 1933).

The upper reaches of the Nogal valley, in the NE and NW Regions of the Republic, are not now occupied by a major watercourse, but in the lower reaches there is a major river which seasonally flows into the Indian Ocean at Eil through a steep-sided gorge.

The deposits of the Nogal consist mainly of a succession of beds of massive anhydrite locally altered to gypsum on the surface. These beds date from the lower to middle Eocene. The south-eastern section of the Nogal is incised straight into the lower-lying areas of Carcar series limestone.

3.6 LAVA AREAS

To the north-east of the Ahl Meskat and to the south-east of Candala there are two large seasonal rivers, Tug Wein and Tug Midleho, which are noteworthy for being the sites of the only lava flows in the Bosaso Region. These basaltic lava flows were canalised by the valleys indicating that the main drainage system was already established. The flows are Pliocene or even Pleistocene in age (Azzaroli, 1957) and outside the river beds all that now remains is a single layer of lava boulders over the limestone.

4. SOILS

In general the rate of soil erosion exceeds the rate of soil formation and mature deep-profiled soils are rare. Most soils are immature or truncated and clearly show their geological origins, and erosion is so general that many soils have been eroded down to semi-stable stone-mantles or bed rock and the eroded material has been redeposited elsewhere. The term 'stone mantle' is here used to cover any truncated soil, soil remnant or skeletal soil which has a layer of stones on the surface (Hemming & Trapnell, 1957).

With the exception of the very small area of lava, most of the Bosaso Region is composed of various limestone strata. Both the rocks and the derived soils are therefore calcareous and this leads to a difficulty in soil analysis. Much of the soil consists of physically weathered limestone broken down to all sizes from coarse sand to clay particle size. This is all removed by acid washing to determine the clay content, and as a result the percentages of the various soil-particle sizes are rather misleading. In the worst example (Table 2, sample 1) some 88.8% of the total soil was removed before analysis began. It is highly probable that much of the calcareous dust in the soil is in the silt particle size-range.

To readers better acquainted with soils of temperate regions this may be surprising, but in this paper it is necessary to use the word 'soil' to include any superficial deposit showing the smallest trades of soil formation. This seems to be the only satisfactory definition for such a condition and it was used in this sense in another semi-arid area (Hemming & Trapnell, 1957).

Table 2

ANALYSIS OF SOIL SAMPLES

Sample No.	% Gravel, fraction 2 mm of sample as received	Analysis of fraction smaller than 2 mm											
		% Carbon (Walkley-Black, uncorrected.)	% Nitrogen	C/N ratio	% Organic matter (%CX 2)	% Coarse sand 2-0.2 mm	% Fine sand 0.2-0.02 mm	% Silt 0.02-0.002 mm	% Clay 0.002 mm	% Calcium carbonate	pH (of a 1:5 soil:water suspension)	Electrical conductivity in millionm/cm at 25°C of a 1:5 suspension	% water soluble salts (estimated from the conductivity figures)
1.	11.4	0.04	0.010	4.8	0.08	1.00	10.06	0.00	0.00	88.8	9.0	0.078	0.06
2.	5.4	0.30	0.040	10.0	0.60	2.50	20.08	10.50	37.90	28.3	8.3	0.185	0.12
3.	29.9	0.11	0.020	7.3	0.22	0.20	9.63	10.25	2.00	76.5	7.8	2.840	1.20
4.	3.4	0.07	0.040	2.4	0.14	1.00	4.89	6.10	0.00	87.8	8.8	0.092	0.07
5.	34.3	0.08	0.020	5.3	0.16	11.30	13.36	3.00	7.10	65.0	8.9	0.114	0.08

1. Bare alluvial soils of Daror, 22 km east of Darin Camp.
2. Brown hill soil, south of Bereda.
3. } Valley-type alluvial stone mantles (5 km south of El Gal.
4. } (11 km south of El Gal.
5. Soil under superficial stone mantle of rounded gravel, 6 km east of Bur Atoti.

These samples are all from the topsoil between the surface and a depth of 15 cm.

5. COASTAL AREAS

Only relatively small sections of the Bosaso Region have a coastal plain because generally the inland mountains and plateaus extend to the shore line, often ending with cliffs into the sea. Along the north coast, quarternary raised coral reefs form much of the coastal plains and remnants may be seen on the face of the cliffs where today there is no plain.

The north-eastern tip of the Somali peninsula at Cape Guardafui rises to 200 m above the sea and is accordingly discussed under the sub-coastal zone. Its peculiarities arise from its elevation and orographic rain rather than from the nature of the soil. Hafun peninsula and the south of the Nogal, described in sections 5.6 and 5.7 are on a purely geographical basis because these areas, though small, are varied and interesting with rather distinctive vegetation. Despite the small extent of coastal plains in the region, there is considerable variation in the vegetation as in this hard habitat, which is frequently saline, small differences in the soil result in a marked change of vegetation. The whole zone must therefore be regarded as a pedologically rather than a climatically controlled mosaic.

To assist the reader and facilitate future studies the names of main places where the types described are found are given in the following index.

Raised coral reefs	
Exposed raised reefs	Bargal
Raised reefs with overlying gravel	Bosaso, Bereda
Raised reefs with overlying marine sand	Alula
Raised reefs with overlying colluvial sandy soils	Candala, Bargal
Raised reefs with overlying saline alluvium	Bargal
Conglomerate plains with overlying marine sand	Hordio
Silty coastal plains	Merhagno-Chesselei
Ancient aeolian sand remnants	Habo, Bolimok
Estuaries and inlets	
Hafun peninsula	
Nogal gorge at Hil	

5.1 RAISED CORAL REEFS

The coastal plains, which are mainly composed of coralline raised beaches, are generally narrow but there are clear signs that they were previously considerably wider. The seaward edges of the raised beaches tend to be covered with deposits of marine sand including dunes of coralline sand, and the inland edges tend to be covered with gravel or colluvial soil and the thickness and nature of any overlying deposits are the principal influences controlling the vegetation.

5.1.1 Exposed Raised Reefs

The two most important occurrences of exposed raised reefs are on the north coast near Bosaso (49.11 E) and on the east coast near Bargal (11.17 N).

On these exposed sections there is no real soil but the coral has been planed level and the interstices have been filled with broken coral, shell fragments and marine sand. There has been only very little rotting of the rock and real soil formation. It is essentially a saline habitat and supports only very sparse vegetation of Limonium. Limonium cylindrifolium is the commoner species on both coasts but in the Bosaso area L. axillare is also found. Limonium is probably the most common genus found on all exposed raised beaches along the Somali peninsula and on both coasts of the Red Sea (Vesey-Fitzgerald, 1955, 1957). In northern Eritrea, where the stony nature of the raised beaches is concealed by a thin layer of locally derived sandy clay (Hemming, 1951), the dominant vegetation is also Limonium.

5.1.2 Raised Reefs with Overlying Gravel

Raised beaches commonly carry a mantle of transported gravel derived from the erosion of either the sub-coastal hills or the Miocene conglomerate beds. In general the stones are less than 10 cm in diameter but in one locality near Bereda (11.52 N, 51.03 E) there are beds of very coarse rounded alluvial gravel with individual stones up to 30 cm in diameter.

If the overlying gravel layer is thin and patchy it has no noticeable effect upon the vegetation and the plants have their roots in the underlying coral soil; Limonium cylindrifolium remains the characteristic plant. A thin but continuous layer of gravel generally causes Salsola rubescens, often with S. forskalii, to replace Limonium. Near Bosaso Ballota sp. was found on thin gravel but this must be regarded as a very local variant as it was not found elsewhere.

Near Bosaso thick deposits of gravel, derived from the conglomerate beds in the Carin gap, are common. These gravel beds support widely spaced low Acacia tortilis trees. The average annual rainfall at Bosaso is only 17 mm which would not alone be enough to support trees. This suggests that underground water, which is common in the Carin gap, is also available here. Acacia tortilis is known to tolerate slight salinity which might also be expected here.

Heavy grazing pressure, in the vicinity of Bosaso, is an important factor in keeping the Acacia down to shrub size. Acacia tortilis growing to about 1 m on the coarse alluvial gravel, near Bereda, is associated with Euphorbia nubica. Most of the vegetation tends to be concentrated along the drainage lines which carry the run-off from the nearby hills.

5.1.3 Raised Reefs with Overlying Marine Sand

Sand is found as a mantle overlying considerable sections of raised beaches. The mantle varies in two main respects; firstly in its thickness from a few millimetres up to several metres and secondly in its degree of compaction which ranges from very soft dune sand to hard, level, wind-packed deposits.

The smallest amounts of sand which had any noticeable effect upon the vegetation were found near Bosaso where the raised beach is crossed by small drainage lines. The plants which tend to concentrate along them collect small amounts of wind-blown sand, and gradually a more favourable habitat is built up. In these areas two Convolvulaceae are found; Convolvulus ruspolii and Merremia somalensis. The latter species is also found extensively in large seasonal inland watercourses.

The coastal plain between Habo and Alula (c. 11.55 N, 50.37 E) is covered by a mantle of sand that is generally thin but locally forms small dunes. In areas where the sand mantle is only 5-10 cm thick the vegetation is still somewhat halophytic. Atriplex coriacea and Salsola forskalii are typical of such sites where the roots occur in both the sand and the underlying coral. Each of these species tends to be dominant within restricted areas.

The thinnest layer of sand which supports non-halophytic vegetation is about 15 cm deep. On the coast of the Bosaso Region the most characteristic species of non-saline sand away from watercourses is the composite Iphiona rotundifolia.

It is not, however, found on live dunes. Where watercourses cross Iphiona sand areas woody species are found, notably Acacia tortilis and Boscia minimifolia, with widely spaced Cadaba glandulosa forming a fringing zone up to 100 metres wide on both sides of the watercourse.

To the east of Bolimok (11.56 N, 50.37 E) there is a section of plain covered with a rather compact type of marine sand with a level deflated surface of coarse sand and small stones which is fairly stable against wind erosion. The sparse vegetation consists of well spaced low clumps of Salsola forskalii together with small numbers of Limonium axillare. Downwind from each plant there is a long thin wind-shadow accumulation of sand. A few hundred metres inland there are small dunes up to one metre high, each of which is fixed by a bush of Cadaba glandulosa. Between these dunes there is sparse Limonium axillare.

To the north of Bargal, on the east coast, where the coastal plain ends and the mountains lie close to the sea, the plain is covered by a mantle of sand. The mantle is of two types: a flat layer of more or less wind-stable compact sand and a patchy mantle of loose mobile sand. In this area the vegetation consists of occasional small Acacia tortilis trees and scattered low clumps of Iphiona rotundifolia. The latter species is mainly restricted to the soft sand while the trees are distributed without regard to the present position of the loose sand. It seems that the soft sand provides a more favourable site for the establishment of young seedlings of both species but only the trees persist after the sand is blown away.

Along some sections of the coast the intertidal sand beach slopes gradually up to the sand-covered coastal plains, and just above the high-tide line there is often a line of low dunes, which are more often composed of coral-derived sand than quartz sand. This type of sand is porous and saline and is usually damp due to the hygroscopic effect of the salt. The dunes usually support Suaeda monoica and Zygophyllum coccineum. This is in marked contrast with similar dunes 400-560 km to the west where grasses, notably Odyssea mucronata, Halopyrum mucronatum and Aeluropus lagopoides, are dominant (Hemming, 1966).

In the Bosaso Region Halopyrum was found at only one restricted locality on the east coast and the other species were not found. On the east coast near Hordio low beach dunes supported Arthrocnemum glaucum

5.1.4 Raised Reefs with Overlying Colluvial Sandy Soils

At certain localities, notably Candala (11.29 N, 49.53 E) and Bargal, the raised coral reef is overlaid with a sandy soil which is composed partly of mixed colluvial material derived from inland areas and partly of wind-blown sand.

Near Candala a sample pit revealed about 30 cm of a mixture of sand, assorted fine colluvial material and small stones on top of the coral. This soil supports no vegetation except where it is overlaid with a mantle of wind-blown sand or along drainage lines. Much of the plain is overlaid with deep loose sand in the form of bare dunes.

The commonest plant on the plain is Heliotropium sp. aff. congestum, a small, densely hispid xerophyte about 7.5 cm tall, which is found all over the wind-blown sand mantle. Associated species found in small numbers include Ruta tuberculata and Salsola forskalii. The largest species on the plain is Acacia edgeworthii, a low flat-topped shrub, which occurs mainly in groups anywhere between the stony pediment areas and the shore line. Watercourses on the plain support the composite sub-shrub, Sclerostephane adenophora to 60 cm, though in some areas it forms dense vegetation with A. edgeworthii (Plate 2). Sclerostephane extends up the drainage lines from the plain as far as the stone litter pediment areas. On the rocky slopes above, low woody species are sparsely distributed: Caesalpinia erianthera, Acacia tortilis and Ziziphus hamur, all in the 1 to 1.5 m height range.

The inland parts of the raised reef at Bargal are overlaid with a darker-toned, colluvial, rather compact sandy loam which becomes very muddy during rain. The effect of a thin layer of this soil is very marked, and within a few metres of Limonium cylindrifolium, on exposed coralline soil, a mixed woody vegetation which includes inland species is found. The main species noted were Acacia edgeworthii, A. tortilis, Commiphora sp. "Gowlello", Ipomoea donaldsonii, Jatropha villosa var. sublobata and Salsola bottae.

In some sections Acacia tortilis is dense and up to 4 m high but on drainage lines it grows to 5 m. These areas show signs of heavy grazing and the ground vegetation consists almost entirely of the unpalatable composite Sclerostephane adenophora.

5.1.5 Raised Reefs with Overlying Saline Alluvium

On the seaward edge of the raised beach to the south of Bargal there are areas of highly saline reddish-brown fine sandy clay which closely resemble much more extensive areas on the coast of northern Eritrea (Hemming, 1961). There are areas of bare salt flat separated by slightly raised sandy areas which support Arthrocnemum glaucum. Drainage lines from inland, less saline, areas support low clumps of Pluchea sp.

Where a larger watercourse crosses a section overlaid with colluwium the vegetation is much taller, consisting mainly of Tamarix nilotica to 4-5 m high, large clumps of Lycium europaeum to 2.5 m and some Arthrocnemum which extends up the watercourses from the area of saline alluvium. The taller vegetation along these watercourses acts as a wind barrier and collects wind-blown sand which accumulates round the trees and bushes.

5.2 CONGLOMERATE PLAINS WITH OVERLYING MARINE SAND

On the east coast near Hordio (10.34 N) the coastal plain appears to comprise a planed shelf of conglomerate with an assortment of superficial deposits, mainly sandy. The conglomerate base is only revealed in the beds of watercourses on the inland edge of the plain.

The superficial deposits comprise fine stony talus at the foot of the low inland scarp, and over the rest of the area there is a layer of compacted sand with its surface deflated to wind stability. On top of the stable sand there is much wind-blown sand which occurs in two forms: an irregular more or less continuous deposit of varying depth and a series of discrete barchans or crescentic dunes.

These conglomerate plains differ from the raised coral reefs which are overlaid with a similar sand in one important respect. This is that the conglomerate is impermeable and therefore encourages lateral movement of water under the sand and prevents growth of any deep-rooted plants, and thus does not provide a deep saline habitat.

The characteristic vegetation of the stable flat sand is occasional scattered small Zygophyllum coccineum, Limonium cylindrifolium and Cymbopogon schoenanthus. The barchans rest upon the surface and are 7 to 9 m high and the surface between the dunes is free from loose sand. The barchans are devoid of vegetation, but their rate of movement is slow enough to allow individual Zygophyllum coccineum to grow a short distance up the bottom of the slip-face.

The main concentration of barchans lies just inland to the north-west of Hordio, they extend in a thin line 32 km northwards. The area of continuous irregular sand lies mainly along the inside edge of the barchan area and may be divided into two sub-types. The first is a continuous sand belt forming a distinct zone in the narrow strip lying between the northern section of the barchan area and the low inland scarp and its associated stony pediments. The second sub-type lies further south where the coastal plain is wider; this area does not support such rich vegetation as the first.

The vegetation of the first sub-type is characterised by numerous Acacia tortilis trees to 3.5-4.5 m. This additional growth is due to the run-off from the stony pediment areas that lie immediately inland. The sand forms a check to drainage and the water is absorbed by the sandy plain. The second sub-type is wider and does not lie close to the stony pediments; consequently it lacks the improved water supply of the more northerly section. The vegetation is very sparse and consists of only scattered Acacia edgeworthii and the xerophytic grass Panicum turgidum.

The inland edge of the conglomerate plain is marked by a low scarp, along the foot of which there is a stony pediment consisting of limestone talus with the underlying conglomerate revealed in the beds of small watercourses. Between the drainage lines the vegetation consists only of very widely spaced low plants; Limonium cylindrifolium, Lycium europaeum, Salsola rubescens and Pluchea sp. Where the pediment is not reduced to a stone mantle, occasional shrubs of Caesalpinia erianthera are found. Small patches of wind-blown sand on the pediment support a few small clumps of Iphiona retundifolia. The drainage lines support low woody bushes including very stunted Acacia tortilis and Euphorbia cuneata.

5.3 SILTY COASTAL PLAINS

In the Merhagno - Ghesselei area (11.42 N, 50.27 E) there is 13.5 km of coastal plain with a pallid whitish, cement-coloured, fine, dusty, silty, alluvial soil. The water table is only about 1 to 1.5 m below the surface and as temperatures and evaporation rates are high there has been some salinification of the soil due to upward movement of water. This area supports large plantations of date palms, separated from the sea by only 2 or 3 narrow zones. Along the shore line there is a fixed dune of whitish quarts sand supporting Iphiona rotundifolia, Salsola forskalii and Ruta tuberculata. Inland from the dune there is a saline zone of hummocky sand up to 300 m wide which supports Suaeda monoica. In one locality this saline zone is about 100 m wide and Suaeda is replaced by Arthrocnemum glaucum. Further inland lie the date cultivations, which, in neglected areas, are being invaded by Limonium cylindrifolium and Pluchea pinnatifida, both growing well to form clumps 60 cm high. The date cultivations are also being invaded on their inland edges by deep wind-blown sand, which moves and is liable to kill the palms but only if they are engulfed deeply and for a long time.

5.4 ANCIENT AEOLIAN SAND REMNANTS

On the coast of the Bosaso Region there are at least three areas of wind-dissected remnants of ancient aeolian sand deposits which are now consolidated and slightly cemented.

The first site seen was on the north coast at Habo (11.47 N, 50.31 E) where there are remnant blocks of hard sand with a maximum thickness of about 0.6 m and the surface deeply wind-dissected. The ancient aeolian deposit is resting on a local occurrence of orange-toned, gritty, coral soil. The sand supports a sparse mixed vegetation of which the most important species is Limonium sp., with some Iphiona rotundifolia and, where the soil is slightly more silty, Acacia tortilis, Atriplex coriacea, Boscia minimifolia, Cadaba glandulosa, Commiphora sp. "Hodei" and small clumps of Suaeda monoica.

The second site lies 21 km to the north-east of Bolimok (11.56 N, 50.38 E). Here the aeolian remnants are found in a sheltered valley and the sand is locally several feet thick. This area supports low Acacia tortilis trees, Cadaba glandulosa and Maerua sessiliflora. Where the superficial sand is loose there is much Iphiona rotundifolia. Drainage lines are developed where the sand is thin and the stream bed exposes the underlying limestone. These support richer vegetation for up to 200 m on either side of the stream bed. In addition to the species listed above there are Acacia sp. "Gumar" and Boscia minimifolia, which is kept down to about 1 m maximum height by grazing pressure.

The third site of ancient aeolian remnants lies in the west side of the Hafun peninsula (section 5.6).

5.5 ESTUARIES AND INLETS

Breaks in the coastline are of two main types. The first is a typical estuary filled with sea water throughout the year except during short periods of spate when fresh water fills the estuary. The second type, which is less common, consists of a long narrow lagoon-like inlet not associated with any watercourse, which has been cut off from the sea by a bar of wind-blown sand parallel to the shore.

5.5.1 Estuaries

Estuaries are sometimes cut off from the sea by steep gravel banks built up by wave action and the vegetation along such partially enclosed stretches of sea water generally consists of a few mangrove bushes, Avicennia marina, on the water's edge and dense stands of Suaeda monoica on the banks which consist of alluvium brought down by the periodic floods. Upstream from the sea-water pool there is an intermediate zone of Tamarix nilotica before the beginning of non-saline vegetation of low Acacia tortilis and Ziziphus hamur.

Just east of Alula the estuary of Tug Galwein is flooded by sea water up to about 1.5 km inland. The whole watercourse is deeply incised into the limestone shelves of the coastal plain. The estuary is seasonally cut off from the sea and there is much evaporation, and evaporated salt deposits can be seen on the banks. The vegetation on the banks consists mainly of Tamarix nilotica, and wind-blown sand piled against the side of the watercourse supports Salvadora persica which gives way to Acacia tortilis and Iphiona rotundifolia above (Plate 3).

One other large estuary was seen at Candala (11.28 N, 49.52 E), where the sea water extends 4 km inland and is not cut off from the sea. Throughout this distance it passes between almost bare limestone hills. The muddy flats that form the inland limit of the sea water support scattered low Suaeda monoica and bushes of Tamarix nilotida. The last section of the river bed has a small plantation of date palms.

5.5.2 Inlets

Tow inlets parallel and close to the coast and formed by wind action were found in the north-east of the Basaso Region. The first and largest, which is at Habo (11.47 N, 50.31 E), is about 13 km long, extending westwards, while the east end tends to be filled in by wind-blown sand. The entrance to this inlet moved some hundreds of metres to the west in 1959. The second and smaller inlet is at Alula (11.58 N, 50.45 E).

The tidal movement in these inlets results in much of the enclosed area being alternately exposed and covered by shallow sea water. Such an area was examined at Alula, and its central part supports a poor growth of mangroves (Avicennia marina). The edges of the inlet, which are less frequently covered by sea water, supports Arthrocnemum glaucum on mounds of sand which have sea water between them at high tide.

5.6 HAFUN PENINSULA

Hafun peninsula juts out from the east coast (10.25 N) and the main island section covers about 260 km^2 being joined to the mainland by a narrow sandy isthmus 16 km long. To the north of the isthmus there is a shallow lagoon and to the south lies the open sea. The peninsula rises to a maximum height between 210 and 240 m and receives between 50 and 150 mm annual rainfall. Only a small section in the south-west of the peninsula was examined, but even this was found to contain a wide variety of habitats, including present-day wind-blown sand accumulations and low stony hill slopes together with watercourses of various sizes. These habitats are all described in this one section because the character of Hafun as a geographical entity would be lost were it to be split up into the different sections of this paper.

On the west shore facing the shallow lagoon, there are hummocks of sand that are surrounded by shallow sea-water at high tide and support Arthrocnemum glaucum, which is also found on the sandy isthmus and the sandy shore on the mainland. Inland from the Arthrocnemum there is an extensive deposit of ancient aeolian sand which has been eroded mainly by the SW monsoon (May-September). This sand is now consolidated and supports very sparse vegetation, with Limonium axillare nearest the shore. The next zone is mixed and must be regarded as transitional as it shows both littoral species (Pleurostelma sp. and Zygophyllum coccineum) and inland species (Acacia edgeworthii, Jatropha villosa var. sublobata and Lycium europaeum.

On the south coast the sandy beach rises steeply from the sea to the coastal plain and the vegetation nearest the sea is the pan-tropical Ipomoea pes-caprae var. brasiliensis on accumulations of wind-blown sand about 100 m from the shore line. The coastal plain between watercourses is generally devoid of vegetation except for a few low woody shrubs of a Euphorbia sp. which resembles E. cuneata. Shallow watercourses in the southern coastal plain support scattered low Pluchea sp., Iphiona rotundifolia, Pleurostelma sp. and Jatropha villosa var. sublobata to a maximum height of 60 cm. Larger stream beds support shrubs of Tamarix nilotica with very occasional Salvadora persica, while Aerva persica and Pleurostelma sp. occur along the edges with Zygophyllum simplex on gravelly sections of the tug-bed. In one watercourse Acacia sarcophylla was seen on sandy mounds.

The cliffs on the south side of Hafun descend straight into the sea and, being exposed to the full force of the SW monsoon, are devoid of vegetation. They show marked signs of wind erosion and sharp edges and overhangs are found. On nearby inland-facing scree slopes scattered clumps of Limonium spp. were found: L. somalorum and a very dense cushion-like species resembling L. kossmatii from Socotra. Inland from these cliffs there are small valleys protected from the wind and often partly filled with blown sand. In one such area the vegetation was mixed and included Acacia sp., Limoniastrum migiurtinorum, Iphiona rotundifolia, Jatropha villosa var. sublobata, Linaria sp. nova, Ocimum tomentosum, Pleurostelma sp. and a very occasional stunted Salvadora persica.

5.7 NOGAL GORGE AT EIL

The Nogal river runs approximately from WNW to ESE for more than 300 km but only contains a substantial watercourse for about the last 100 km. It finally reaches the sea through a deep gorge, cut through limestone strata and conglomerate at Eil. The river is seasonal but during the periodic floods, which are large, alluvium can be seen discolouring the sea up to at least 1.5 km from the shore. The sides of the gorge are steep and rocky but well weathered and beneath the superficial stone mantle there is an orange-brown, gritty loam which is able to support quite rich vegetation. The gorge presents a wide range of habitats.

5.7.1 Pools in the Main River Bed

Between periodic floods all that remains is a series of small pools connected by small streams. The pools support Paspalum vaginatum around the edge and outside this there is often a patchy sward of Sporobolus spicatus on the surrounding sand. Beyond this grass zone there are dense stands of Tamarix nilotica on the alluvial banks, but these are only found near the permanent pools. On the main banks outside the Tamarix there is a narrow zone of scattered low Suaeda bushes at the foot of the rocky valley slopes.

In the bottom of the valley there are also remnant blocks of ancient hard alluvium which supports inland species: Acacia tortilis to 2 m and Lycium europaeum to one metre, together with halophytic species: Limonium axillare and Limoniastrum migiurtinorum. Gravelly sections of the river bed support only scattered small plants; Lasiocorys argyrophylla, Limonium axillare, Pulicaria sp. and Solerostephane adenophora.

5.7.2 Valley Slopes

The vegetation of the valley slopes is very mixed, consisting mainly of low woody species as the valley is a stock route between Eil and Badei. Near Eil the dominant species are typical of the Sub-coastal areas, consisting of Acacia reficiens subsp. misera and Caesalpinia erianthera var. erianthera, with fewer but taller Dobera glabra, Salvadora persica and Commiphora sp. nova. Other important species include Euphorbia cuneata, E. somalensis var. nogalensis, Cassia ellisae, Boscia minimifolia and Maerua sessiliflora. The small ungrazed composite Solerostephane adenophora is locally quite dense.

Lower down the gorge towards Badei the vegetation is generally lower and more mixed, consisting largely of species such as Capparis cartilaginea, Limonium, Limoniastrum migiurtinorum, Zygophyllum coccineum, and the small succulent Lithocaulon. The unpalatable composites Iphiona rotundifolia and Solerostephane adenophora are also quite common.

5.7.3 Gullies

Along the sides of the gorge there are some steep sections where gullies have been formed. They are mainly found on the southern side of the river which is protected from the SW monsoon. The superficial soil in these gullies has been eroded but enough remains below the stones to support occasional thickets 3 m high of almost pure Rhus puccionii, and in other areas low Acacia reficiens subsp. misera is dominant with Caesalpinia erianthera var. erianthera.

At the edge of these gullies the vegetation soon changes to the mixed vegetation described above. In an intermediate transition zone species not found elsewhere include Kirkia sp. of. tenuifolia, a bushy tree to 2.5 m, Acacia mellifera, Poskea socotrana and Salvadora persica.

5.7.4 Limestone Shelves

In some sections the valley slopes are interrupted by approximately level shelves of limestone where a hard stratum has resisted erosion. Small Caesalpinia erianthera var. erianthera bushes are dominant on these shelves and there are also a few tufts of Pulicaria sp. and the prostrate Aristolochia rigida.

5.7.5 Cliff Tops

The tops of the cliffs on the north side of the gorge show signs of exposure to the SW monsoon and generally consist of completely bare rock. Small dense cushion-like wind-resistant plants are found, one, Pulicaria sp., growing along cracks in the rock, and the other, Oldenlandia saxifragoides, in slight depressions on the otherwise bare rock. Other species found were a very small prostrate Jatropha sp. nova, a larger prostrate Commiphora and an acanthaceous species (Plate 4).

5.7.6 Caves

In the face of the limestone cliffs there are occasional caves in the softer strata. These have a floor covering of fine powdered and broken litter. In this soil and the half-light of the cave the only species found was Sutera lyperiiflora.

5.7.7 Coastal Plateau

Near the village of Eil there is heavy grazing pressure and above the gorge near the town the only species which survives is Convolvulus ruspolii.

5.7.8 Sandy Beach

The beach below Eil at Badei on the east coast (7.58 N) is wide and sandy. Along the shore line there is a zone of Zygophyllum coccineum which becomes mixed with dwarf Lycium europaeum and numerous small Tephrosia filiflora. In the inland section of this mixed zone Z. coccineum is found mainly on low hummocks of wind-blown sand. Cassia senna var. obtusata to about 15 cm high is found scattered all through the Z. coccineum zone to within about 50 m of the sea. At the top of the beach, at the foot of the cliffs, there is a zone dominated by Limoniastrum migiurtinorum, with a few very small Tephrosia.

6. SUB-COASTAL ZONE

6.1 GENERAL DESCRIPTION

In Hemming (1966) the Sub-coastal zone was defined as the zone between the true coastal plains and the slopes of the main escarpment along the whole length of the NW and NE Regions.

The mean annual rainfall figures available from stations within the Sub-coastal zone of the NW and NE Regions vary between 100 and 250 mm and the altitude varies from a little above sea level to some 700-800 m. In the NW and NE Regions the dominant genera of the most important communities are Acacia and Commiphora.

The Sub-coastal zone in the Bosaso Region is similar in most respects. Records at Scusciuban and Gardo (Table 1) indicate a mean annual rainfall of 60 mm and 111 mm respectively; the altitude range is from a little above sea level to the edge of the lower limit of the Acacia bussei open woodland near Gardo at 690 m and to the lower limit of the Evergreen scrub in the watercourses of the eastern Ahl Meskat below Galgallo.

The main differences between the Bosaso Region and the NW and NE Regions in respect of this zone are that in the Bosaso Region much of it lies far from the sea, that it contains much more extensive areas of grassland and that its position in the ecological succession is different.

In parts of the Bosaso Region the upper limit of the Sub-coastal zone is Evergreen scrub with no intermediate zones of either Acacia bussei or Acacia etbaica open woodland; in the two areas where this succession was observed Acacia mellifera was an important plant in the ecotone between the Sub-coastal zone and the Evergreen scrub.

A further peculiarity of the Sub-coastal zone in the Bosaso Region is that it extends to the sea along large sections of the coastline. The inland plains which characterise it extend to the sea where they end in steep cliffs and no intermediate coastal plain. There are signs, particularly on the north coast, that coastal plains formerly existed where none exist today.

To the south of Bosaso in the Carin gap, which separates the Ahl Medo in the west from the Ahl Meskat in the east, the altitude increases gradually southwards and in this particular area the boundary between Coastal areas and the Sub-coastal zone is somewhat arbitrary.

Owing to the generally low rainfall (Fig. 3) and the low altitude that prevails over much of the region, the Sub-coastal zone is much the largest zone. It includes a wide range of geological and soil types varying from alluvial soils to stone mantles of alluvial or residual limestone and lava.

Another effect of the large size of this zone is that it contains a considerable range of plant species; thus while many species may be found throughout the zone others have a very local distribution, and species of the latter type are particularly characteristic of watercourses, particularly the Nogal gorge at Eil where many endemic species are found.

To facilitate the description of this enormous zone (Fig. 2), which includes the most important grazing areas of the Bosado Region, some areas that show sufficient ecological uniformity are described as geographical entities. The zone is described under four subdivisions: Eastern Ahl Medo, Carin gap, Daror depression and Eastern lowlands.

6.2 EASTERN AHL MEDO

The eastern end of the Ahl Medo range is just within the boundary of the Basado Region and forms the western side of the Carin gap. The highest point visited was at 1160 m in the Evergreen scrub near Galgallo. Below 1130 m there was mixed bush more typical of the Sub-coastal zone and between 910 and 680 m there was much Acacia mellifera which is characteristic of the wetter and higher sections of sub-coastal vegetation. This represents a wide transitional belt where the zones overlap, as evergreen species are found along the watercourses down to 680 m.

In the upper transitional area the main species are: Jatropha robecchii, Lannea obovata, Turraea parvifolia, Kleinia longiflora, Adenia gallyi and a small spiny Euphorbia sp. It is not possible to characterise this zone by a dominant species.

Part of this zone consist of pavements of rock with small pits in which the small succulent Lithocaulon cubiforme is commonly found.

In this zone the tops of large boulders and smooth sloping rock faces support Lannea obovata, a 2 m tree with a cushion-like sucker and no normal root system. In its growth form it is similar to Boswellia carteri.

In a single sheltered gully with a small seasonal stream and some accumulation of soil, Ficus sp., Salvadora persica and Sansevieria ehrenbergii are found. Below 910 m within the zone where Acacia mellifera thrives other species found include Acacia horrida subsp. benadirensis, Euphorbia cuneata, E. noxia var. menleniana, Boscia minimifolia, Maerua sp., Sarcostemma viminale, Aloe scobinifolia and the succulent-stemmed Cissus betiformis.

Galgallo is situated at 900 m and is an oasis in the dry mixed bush. There is a spring of clear sweet water which is used to irrigate small bunded fields. The most characteristic natural vegetation of the oasis is the tall unbranched palm, Hissmania carinensis, which attains 30 m. Hissmania palms are also found in the lower oasis at Carin, but it is a rare tree. There are also large Ficus vasta trees, and Delonix regia, a large ornamental tree, is also common. Throughout the oasis the most common trees are date palms which are extensively cultivated. Other important crops are bananas, pawpaw, lemons, custard-apples, sweet peppers and chilies (Capsicum spp.), and sweet potatoes.

A narrow fringing mat is found along the sides of the irrigation ditches and comprises Cynodon dactylon, Dactyloctenium aegyptium, Echinochloa colona and Phyla nodiflora; and in shady areas ferns occur.

Other small plants found throughout the oasis, particularly in the drier uncultivated areas, include Hypoestes forskalii, Lasiocorys argyrophylla and Solerostephane adenophora, all of which suggest considerable grazing pressure.

6.3 CARIN GAP

6.3.1 General Description

The Carin gap is the lowland area that separates the east end of the Ahl Medo from the west end of the Ahl Meskat. The gap has been cut deeply into the Oligo-Miocene beds of conglomerate and much of the derived gravel, has been covered by a thin 30-cm layer of more recent limestone, possibly formed when the Carin gap was invaded by the sea in the mid-to late-Miocene. Now only a small portion of the floor of the Carin gap is occupied by watercourses, which usually have sand and loose gravel in their beds but locally are eroded down to solid conglomerate. There is often some underground flow of water through the sandy and gravelly alluvium, but where the impervious conglomerate is exposed the water is forced to the surface and a stream, with pools in irregularities in the surface, is formed.

This section of the survey includes the exposed residual areas and redeposited alluvium produced during and since the formation of the Carin gap. Here there is a wide variety of habitats: watercourses (varying from minute drainage lines to larger seasonal rivers), low hills, gravel banks and an oasis.

There are no meteorological records available from this area but in general Carin (10.59 N, 49.13 E), which is situated at 335 m, is both hot and arid. When the author was there in September 1959 maximum temperatures exceeded 38°C and the mean annual rainfall probably lies between 50 and 75 mm.

The area is described below under the following headings: low hills and stone-mantle areas; the watercourses succession; the oasis and cultivations.

6.3.2 Low Hills and Stone-mantle Areas

The main area of low limestone hills is centred around a point about 16 km south of Carin at a general altitude of 490 m, and the hills appear to be the remnants of deeply dissected pediments of the south-west Ahl Meskat. The slopes are generally steep and stony with very little soil. In general these hills support no vegetation except along drainage lines.

There are also low hills immediately surrounding Carin and they carry rather more soil than the main block further south. The soil is generally rather saline and the vegetation includes several distinctly halophytic species. Plants are in general small and widely spaced and most of the surface is quite bare.

The commonest halophytes found here are Limonium carinense, L. axillare and Salsola rubescens. In addition, the following species were found scattered about the hills in very small numbers: Acacia reficiens subsp. misera, Cadaba glandulosa, Curroria migiurtina, Maytenus senegalensis and Commiphora sp.

On the floor of the Carin gap to the north of Carin there are extensive stone-mantle areas of redeposited alluvial gravels derived from the conglomerate beds. These gravels support only very sparse vegetation consisting of scattered low Salsola rubescens and Limonium axillare. The gravelly deposits have locally been dissected to a depth of 3-5 m, which is probably near the underlying conglomerate. These gullies normally have water in the bottom and contain dense stands of Phoenix reclinata, with Salvadora persica and low Acacia tortilis on the slopes. Overlying the gravel banks there are remnant patches of a fine silty sandy alluvial mantle. The vegetation of these patches is halophytic, including Limonium axillare, Sevada schimperi and Zygophyllum hildebrandtii, with smaller numbers of Cadaba glandulosa, C. mirabilis and stunted Ziziphus hamur.

6.3.3 The Watercourses Succession

On the main group of hills to the south of Carin the richer vegetation associated with the increasing size of the watercourses can readily be seen.

(a) *Caesalpinia erianthera*

On the bare hills vegetation is restricted to small drainage lines and the last few feet of the slopes down to them. Here the flow of water is so small that the soil in the drainage lines is more or less the same as it is on the slopes. The vegetation along the drainage lines consists of widely-spaced low bushes of *Caesalpinia erianthera*.

(b) *Cymbopogon* - *Curroria*

This type of watercourse is found lower down the slopes after two or three drainage lines of the above type have joined. There is a distinct but narrow stream bed a few feet wide with a small amount of colluvial soil. Here the characteristic vegetation is low clumps of the grass *Cymbopogon schoenanthus* with a few 1 to 1.5 m shrubs of *Curroria migiurtina*. A few *Caesalpinia erianthera*, from the smaller watercourses, and very occasionally *Mimusops angel*, from the larger ones, may be found.

(c) *Mimusops angel*

Watercourses with *Cymbopogon* and *Curroria* join together to form larger ones up to 10 m wide. They are usually incised into the loose stony material from the hills and often have a smooth bed of solid conglomerate. In these watercourses the vegetation is restricted to the edges by the speed of the water and characteristically consists of an interrupted line of mature *Mimusops angel* trees (Plate 5). Their trunks commonly have a circumference of 4.5 m. No seedlings or young trees of *M. angel* were seen and this species does not seem to be regenerating and will probably disappear from these watercourses.

As *M. angel* is a large hardwood tree, it could become a valuable source of timber and might also be used as a shade tree in towns and villages. It protection and propagation should be considered. The absence of seedlings may be due to grazing pressure but this could be established experimentally. *M. angel* is found over wide areas of the Bosaso Region and could possibly be established in wetter areas which might promote more rapid growth.

(d) *Conocarpus lancifolius*

The largest watercourses, formed by the junction of several of the above kind, may be up to 100 m in width. The river bed consists mainly of assorted alluvial gravelly material and the banks often carry remnants of ancient, more sandy alluvium. The flow only occupies the whole width of the bed during very heavy floods, while the smaller flows are restricted to the more incised portions.

These larger seasonal river beds are typified by tall *Conocarpus lancifolius* trees up to 18-25 m (Plate 6). Other large trees include *Ziziphus mauritiana* and *Acacia tortilis*. *Moringa peregrina* is also quite common but only grows to abour 3.5 m in height. Gravel banks at the side of the river bed often support numerous *Balanites* shrubs to 2.5-3 m. Stony slopes down to the edge of the river bed frequently have bushes of *Salvadora persica* and *Ziziphus hamur*, while relict banks of sandy alluvium typically support *Ficus salicifolia*. Smaller plants that are found on the gravelly banks anywhere in the river bed are *Merremia somalensis*, *Ochradenus baccatus* and clumps of *Pennisetum divisum*.

In one large watercourse (tug) there is no single clearly defined stream bed but a braided network of equally important ones which flow into and out of each other. Such a diffuse system results in a more even distribution of Conocarpus trees which locally may amount to a forest. Under the trees there is usually a layer of dead leaves which dry rather than rot, and here no other species are found.

In all these areas abundant Conocarpus seedlings were found and this species seems to be secure along the larger watercourses. Its timber is exported for the building of dhows but cutting is controlled by local law. Conocarpus appears to have a very restricted habitat centred around Carin, but it reproduces readily and is widely used as an ornamental tree.

6.3.4 The Oasis and Cultivations

(a) Carin Oasis

In the area of Carin oasis the water table is generally within one metre of the surface, which is stony or gritty, puffed-up and somewhat saline. The oasis, which supports quite dense vegetation, is characterised by the tall unbranched palm Wissmania carinensis to 30 m (Plate 7). The denseness of the vegetation is due to smaller palms, principally Phoenix reclinata with smaller numbers of Hyphaene reptans. Other important plants are Tamarix nilotica and 3 m clumps of the grass Saccharum ravennae. Within the oasis there are a few trees typical of the neighbouring river beds, Conocarpus lancifolius and Mimusops angel, and around the edge of the dense vegetation there are bushes of Maerua, Salvadora persica and Taverniera abyssinica. Wissmania carinensis is the tallest palm growing in the region and it has an extremely limited distribution. It can provide timber for building, but uncontrolled cutting now threatens the species with extinction and its immediate protection is recommended.

(b) Cultivation

In one nearby river bed there is a very small permanent stream flowing over solid conglomerate. The stream has been diverted on to the river banks which consist of deep alluvium. The irrigation ditch flows along the outside of some Conocarpus forest and supports 2.5 m shrubs of Serra inoana, large clumps of Saccharum ravennae and smaller subshrubs of Sclerostephane adenophora. The irrigation water is used to support a small garden of date palms and there are signs of salinification of the soil, but the palms seem salt-tolerant. Around the edge of the irrigated area are Tamarix nilotica and Phoenix reclinata which are also quite salt-tolerant.

6.4 DAROR DEPRESSION

The Daror depression lies to the south of the WNW-ESE fault, which forms the south side of the Ahl Meskat. The floor of the depression varies in altitude between 400 and 640 m and the general slope is down to the south-east. The base of the depression consists largely of lagoonal sediments laid down in the Miocene, together with deposits of upper conglomerate produced during the weathering of the scarp face and other finer alluvial deposits. Conglomerates and coarse alluvial gravel are plentiful near the foot of the Ahl Meskat, and deposits of gypsum are found near Meleden (10.25 N, 49.50 E).

The Daror depression has an estimated annual rainfall of 100-150 mm but also receives some run-off from the mountains to the north. The temperatures are generally high with considerable cooling at night. Although there is much rain-water run-off from the mountains, it is noticeable that the watercourses hardly extend beyond the stony pediment areas that skirt the mountains. Beyond this limit the water is absorbed by the soils of the plain. The main soil of the depression is a highly calcareous, fine sandy alluvium containing stones (Table 2, sample 1). This has been locally deflated to form limited patches of fine stone mantle of wind-blown quartz sand.

The vegetation is largely restricted to the sandy patches while the alluvial soil is more or less bare except along shallow drainage lines. The alluvial soil absorbs water slowly and in heavy rain there is considerable run-off in the form of sheet flow. Some water goes into the soil, but the smooth surface with sheet flow provides a difficult site for colonisation. At the edge of the drainage lines the surface is rough and the water flowing for some time after the rain allows further penetration. Where there is a superficial sand mantle there is no run-off and although the sand may be expected to have a low field capacity it provides a temporary reservoir from which the water drains slowly into the underlying alluvium and in addition the surface is easier to colonise. The sandy areas also act as partial traps for the sheet flow from higher areas. It is noticeable that the sandy areas, in addition to supporting more vegetation, become green much more quickly after rain. Deep deposits of sand covering small areas were found to have little effect on the vegetation, and it seems that the sand mantle must cover a certain minimum area before it can affect the water balance of the underlying soil and produce a response in terms of richer vegetation. In the north-western part of Daror a series of water tanks were observed under construction. There was only about 30 cm of sandy soil over 1.0-1.5 m of coarse gravel, with massive limestone at about 2 m. In one pit a thin lateritic layer was seen at 1 m. The texture of the top soil varies considerably from a coarse silty sand to silty loam. Examination of the soil analysis results (Table 2, sample 1) is somewhat misleading as 88.8% of the soil consists of calcium carbonate. Much of this is, in fact, very fine and it is this soil fraction that is probably the factor limiting permeability.

The most characteristic plant of Daror is the low tussock grass *Dactyloctenium robecchii*. In 1959, in an area where the sand mantle was continuous for several hundred metres and was 30-60 cm deep, a transect was made. *D. robecchii* made up 71% of the total plants. Other species consisted of *Chrysopogon aucheri* (12.9%), *Iphiona rotundifolia* (10.8%) and *Euphorbia cuneata* (3.2%). Other species which were seen but did not occur in the transect included *Boscia minimifolia* to 2-2.5 cm, *Jatropha villosa* to 60 cm, *Ochradenus somalensis* to 1m and *Cynanchum defoliascens* to 30-45 cm. *Littonia revoilii*, a small lily, was also found in considerable numbers in flower immediately after the rain.

When the Daror was visited in 1959 there were few signs of serious overgrazing, but in 1970 a deterioration was noted. The main indication was the presence of larger bare patches and clumps of *Andropogon kealeri*. This grass in an area of such low rainfall indicates increasing run-off (Hemming, 1965). The presence of small amounts of *Chrysopogon aucheri* over most of the plain probably indicates that this species was dominant before grazing pressure became so severe.

A major cause of overgrazing is the presence of permanent water at Offen which is piped from a spring in the mountains some 10 km away. This water supply has resulted in the establishment of a village and a herd of cows which never move far from the water and a seriously overgrazed area is now well established and increasing around the village.

The vegetation described above covers most of the depression, but some minor variants were noted towards the edges.

(a) In 1959 in the western extremity of Daror a slightly richer vegetation was noted. It appeared to be due firstly to the area being covered with a sandy topsoil instead of patches of wind-blown sand, and secondly to there being more available water owing both to slightly greater rainfall and to run-off from the hilly ground to the west; the whole area was crossed by a braided network of drainage lines. The sand formed a surface which readily absorbed water, and the braided system of drainage lines provided a well distributed supply of extra water without the disadvantage of sheet flow. Here the vegetation also consisted of clumps of Dactyloctenium robecchii with large numbers of scattered low bushes of Acacia sp. which are kept down to about 1 m by grazing. In this area in 1970 large bare areas were noted, indicating greatly increased run-off. Along the side of the vehicle track there were lines of young Acacia trees and grass clumps. Such an area could almost certainly be improved by some kind of contour ploughing to prevent sheet flow.

(b) In the eastern part of Daror to the north of Scusciuban (10.18 N, 50.14 E) there is calcareous alluvial soil containing many small stones up to about 5 cm in diameter. This soil is partly reduced to a stone mantle and is very shallow, less than 30 cm, overlying solid conglomerate. The area is bare except in drainage lines and superficial sandy patches. The patches of sand here are more clearly delineated than those in areas further west and the vegetation is considerably denser. As it is likely that the shallow soil over solid conglomerate would inhibit the growth of bushes and low trees, it seems likely that the distribution of the patches of vegetation may be correlated with areas of deeper soil over breaks or undulations in the underlying rock. The wind-blown sand has probably collected around the vegetation while further west the low grass steppe has developed because of the sand.

The woody vegetation of the sandy patches includes Acacia horrida subsp. benadirensis, A. edgeworthii, Ziziphus hamur and Euphorbia cuneata. The main elements of the lower herbaceous vegetation are Merremia somalensis, which grows in large low clumps, Iphiona rotundifolia and the grass Cymbopogon schoenanthus. This last species is very shallow-rooted and much was found to be dead. The sand was quite dry and it is probable that the grass would not be able to draw any water from the underlying soil.

(c) On the north side of the central sandy areas, along the foot of the Ahl Meskat scarp, there are extensive gravelly pediments which support scattered low bushes of Acacia horrida subsp. benadirensis, A. tortilis, Ziziphus hamur, Euphorbia cuneata and Merremia somalensis. The last species is the only common non-woody plant. These gravel banks are cut by numerous watercourses, along which additional species are found, including Boscia minimifolia, Cadaba heterotricha ahd Moringa peregrina.

6.5 EASTERN LOWLANDS

This section of the Sub-coastal zone includes the lowest and hottest areas with the least rainfall; but the occurrence of Boswellia carteri and B. freereana only a few metres above sea level on the cliffs that mark the inland edge of the coastal plain at Bargal lends support to the view that in the Bosaso Region, even at these low altitudes, mist, dew and condensation play a significant role in ameliorating the arid climate.

In general terms the Eastern Lowlands consist of low hills, undulating plains and dissected areas where stone mantles alternate with flat areas of soil which vary from a few hundred metres to many kilometres in width. At its simplest the vegetation of this area may be summarised as low woody genera, such as Acacia and Caesalpinia, on the stone mantles, and grass genera such as Dactyloctenium, Chrysopogon, Sporobolus and Andropogon on the soil which characterises the most extensive grasslands of the Bosaso Region. Within the grassy areas there is a much greater degree of homogeneity and a smaller number of species involved than in the stony areas.

As in the Daror depression, the dominant grass is Dactyloctenium robecchii, which grows in clumps which may attain 50 cm in height and more than a metre in width. In the wet season when the grass is green and actively growing it is grazed, but when it is dry it is very sharp and prickly and hence unpalatable. This may, at least in part, account for its dominance. In many areas traces of Chrysopogon aucheri var. quinqueplumis can be seen between the D. robecchii clumps. From historical reports (Hemming, 1966) it is clear that Chrysopogon was formerly much more extensive than it is today. In some of the smaller areas of soil which are surrounded by stone mantle from which there is considerable run-off, Chrysopogon aucheri is found in the central and wettest areas (Plate 8). This indicates either that the additional water supply is enabling it to survive under the heavy grazing pressure or that it may be on the verge of becoming a climatic relict, but for the reasons given by Hemming (1966) and Mitchell (1963) it is to be hoped that this valuable pasture grass may survive and indeed increase.

The most typical grass to be found on the colluvial soil areas surrounded by stone mantles is Sporobolus ioclados (Smarginatus). The soil in these areas is characteristically fine and owing to heavy grazing the cover of S. ioclados seldom exceeds a small percentage despite its dominance. Sporobolus ruspolianus is commonly associated with S. ioclados but usually in slightly better areas, notably those less grazed, better drained or provided with some additional water supply from run-off. The ecological significance of S. ruspolianus in these areas is difficult to assess because it is particularly characteristic of slightly gypseous soils. It produces a creeping stem which may extend for several metres provided that it is protected from grazing for only a month or two after rain. It seems likely, therefore, that poor areas of this species could be improved rapidly under some form of grazing control.

It is clear that unduly heavy grazing, even in this wide area of low rainfall, has resulted in a much reduced grass cover. The existence of grass clumps newly grown in the shallow depressions of ancient vehicle tracks suggests that some harrowing of the surface would encourage the recolonisation of the bare areas by reducing surface flow and trapping the grass seeds (Plate 9). In some areas there are patches of Andropogon kelleri; under such low rainfall conditions this clump grass is characteristic of areas of run-off, as has been demonstrated in the vegetation arcs of the NE Region (Hemming, 1965).

Some 80 km to the north of Sousciuban there are a number of areas of fine soil with sparse overgrazed Sporobolus ioclados. On the bare surface, run-off is considerable and in some of these areas water tanks are being constructed in the form of pits in the ground which reveal a sandy clay loam to a depth up to one metre, with some calcareous flecking, and below this gravel and solid limestone.

In another similar area with S. ioclados a pit exposed approximately one metre of yellowish (10 YR 7/6) sandy loam, easily breaking down to dust when dry and forming deep mud tracks when wet. The dry surface has a finely cracked, flaky, silty surface with considerable signs of sheet flow.

The relationship between the tracts of fine soil and grasses described above is general over very large areas, but the exact proportion of the different species varies considerably from place to place and in the southern parts of the Eastern Lowlands Sporobolus ruspolianus is generally more important than S. ioclados.

There is an interesting variant in the extreme Eastern Lowlands near the sea where the vegetation is denser but stunted, suggesting that it grows better with the humidity and mist from the sea but that the plants are stunted owing to their exposure to the wind. This belt, which is restricted to the last few kilometres from the cliffs to the Indian Ocean, is considerably denser and more varied than further inland. This can be seen particularly clearly above Bender Beila (9.30 N), where there is a stony soil and some wind-blown sand over solid rock, and the zone of richer vegetation extends some 16 km inland. In some places the vegetation is so thick that it is difficult to walk through. In general the vegetation is all stunted, and Dobera glabra, normally a tree to 4 m, grows only to a little over 1 m and is the tallest plant. Other important species and their respective heights are as follows:- Acacia edgeworthii 1 m, A. horrida subsp. benadirensis 30 cm, A. nubica 60-90 cm, Balanites "Scillin" 25 cm, Convolvulus ruspolii 25 cm, Euphorbia somalensis 50 cm and Salvadora persica 30-100 cm.

In this area dominated by woody species the commonest grass is Dactyloctenium robecchii, and other common grasses are Chrysopogon aucheri, Cymbopogon schoenanthus and Sporobolus ruspolianus.

6.6 STONE-MANTLE AREAS

Stone mantles have been developed over wide areas and here three principal types are described, two being characteristically found on plateaus while the third is developed from stony alluvium deposited in lower-lying areas.

Some stone-mantle types have already been described in the account of the Carin gap because the Carin gap is an important geomorphological unit.

Stone mantles are found in almost every major area described in this paper; they are separately described here only where they dominate the scene. They can be classified as residual plateau stone mantles; alluvial stone mantles; lava stone mantles.

6.6.1 Residual Plateau Stone Mantles

In the area to the north-east of Daror there are large stretches of low limestone plateau, at altitudes between 200 and 300 m.

This plateau is covered with a layer of irregularly shaped stones and a fine dusty soil. The soil is grey in colour and is similar to sample 5 (Table 2) which was collected further north. If the superficial stones are moved much dusty soil is found beneath and wind erosion is now only active on vehicle and stock routes. The fine powdery calcareous soil causes poor permeability and after heavy showers there is considerable run-off, particularly when the stones are small and the surface is smooth.

On this stone-mantle plateau, where the estimated mean annual rainfall is between 100 and 150 mm, the vegetation is very sparse and bare areas are common. The most important genus is Acacia and three species are found: A. edgeworthii, A. horrida subsp. benadirensis and A. tortilis. All are stunted below 1.5 m. Regeneration is poor and very few seedlings and young bushes were seen, bare patches of stone mantle being difficult to recolonise. The low Acacia trees are normally found in groups associated with numerous grass clumps of Dactyloctenium robecchii. On one section of the plateau Ipomoea anemophoba was dominant though sparse.

On the plateau there are also occasional small accumulations of wind-blown sand which support somewhat more plentiful vegetation in which Merremia somalensis is characteristic.

To the east of Gargore (10.28 N, 50.41 E) there is a section of plateau situated at nearly 300 m altitude and completely exposed to the SW monsoon. On the stone mantle surface there is a thin patchy layer of wind-blown sand supporting a special vegetation. No small herbaceous species were found but only slender woody species up to 3-4 m able to bend with the wind. The dominant plant is Caesalpinia (specific status uncertain) and its only common associate, with an identical growth form, is Maerua thompsonii.

6.6.2 Alluvial Stone Mantles

Two principal types of alluvial stone mantles are encountered. The first overlies the residual plateau type described above and the second has been derived from finer gravelly alluvium in low-lying sites.

On the higher sections of the plateau, that lie to the south-east of the Ahl Meskat at altitudes over 300 m, there is a mantle of rounded alluvial gravel on top of the residual stone mantle. A sample of the underlying soil was collected and its analysis is given in Table 2, sample 4. The vegetation is very similar to that on the lower-lying angular stone mantle but includes more species, as might be expected in a higher area with a slightly greater rainfall. The additional species found include: Boscia minimifolia, Euphorbia cuneata and Turraea parvifolia. The vegetation is sparse and none of these species is obviously dominant. Where the stone mantle is less developed and soil is visible on the surface, low clumps of Dactyloctenium robecchii are found. As in the lower areas, there are occasional small shallow patches of wind-blown sand which support the species named above and also Ziziphus hamur.

The area that lies between the Ahl Meskat and Ahl Bari undulates between 300 and 450 m. Most of it consists of hill remnants or is covered by some kind of alluvium of which there are two principal types: one type is an alluvial gravel of rounded pebbles of limestone up to 15 cm in diameter, and the other, which frequently overlies the former, consists of an orange-coloured fine sandy deposit containing small stones. The alluvium is found as a hard cemented deposit and is locally deflated to form a fine stone mantle. There appears to be no profile development, and this lack also points to an alluvial origin.

Two samples of the soil below the stone mantle were collected (Table 2). The first (sample 2) was covered with stones up to about 0.5 cm in diameter and this soil contained 29.9% of gravel larger than 2 mm; the second sample (sample 3) was appreciably less gravelly, containing only 3.4% larger than 2 mm, and here the mantle was developed only in small isolated patches in which the stone fraction was higher.

The soil represented by these two samples must be regarded as being at the transition point between a conventional soil and a stone mantle. In both cases the alluvium was about 1.2 m deep and overlay coarse rounded alluvial gravel.

The vegetation of this gravelly alluvium is very sparse and is mainly restricted to woody bushes in drainage lines; these are Boscia minimifolia, Caesalpinia erianthera var. erianthera, Commiphora spp. "Garon" and "Hagar", Euphorbia cuneata, Grewia erythraea and Ziziphus hamur. Smaller, less woody species include Indigofera and various composites.

In a medium-sized watercourse with a stream bed of coarse alluvial gravel Acacia tortilis, Lannea malifolia and Terminalia polycarpa were seen.

6.6.3 Lava Stone Mantles

Restricted basaltic lava flows are found in Tug Wein and Tug Midleho (11.25 N, 50.00 E). The profile at the river bank shows quite thick flows of lava, but on top of the banks all that now remains is a layer of lava boulders and stones on top of a pallid limestone-derived soil. Genuine lava-derived soil is hard to find, the products of lava weathering having become mixed with the underlying limestone-derived soil. A small accumulation of pure lava-derived soil was found in a site protected by lava boulders. It was 1.2 m deep without any apparent variation throughout its profile and consisted of a pale fawn-brown gritty clay with numerous calcareous concretions amounting to 20-40% of the exposed surface.

The vegetation of the lava stone-mantle areas is very sparse and limited to small watercourses, where a broken line of Caesalpinia erianthera bushes with low Acacia tortilis and Commiphora sp. "Hodei" occurs.

The lava has now been eroded away from the bed of the tug and the vegetation does not seem to be affected by any lava-derived alluvial additions.

6.7 WATERCOURSE VEGETATION

Within the watercourses of the Sub-coastal zone there is a very wide range of vegetation which cannot be described fully here. The vegetation is controlled by several factors of which the most obvious is the size of the watercourse. The succession with increasing size has been described in the Carin gap. Other factors include such features as the nature of the river bed, e.g. sandy or conglomerate, and the locality. Certain species are markedly localised within the region, probably by climatic factors.

Conocarpus lancifolius has been mentioned as occurring in the Carin gap which appears to be its natural habitat. The gap is the only place where numerous large trees are found and reproduction is prolific. Mimusops angel occurs with Conocarpus in the Carin gap but it has a much more general distribution, being found throughout the lowlands of the Bosaso Region.

In the north-eastern part of the Bosaso Region there are large numbers of Acacia ankokib (Plate 10). This species is locally owned and produces a somewhat inferior kind of incense-like resin. Associated with A. ankokib is Bridelia somalensis, which occurs over a much wider area, being found in large numbers in e.g. the watercourse leading from the Daror depression to the spring at Offen in the SE Ahl Meskat. The gravel beds of some of the wider tugs support a dense growth of Indigofera oblongifolia, which was also found in the seasonally flooded area at Meleden.

7. ACACIA BUSSEI OPEN WOODLAND

Acacia bussei open woodland and its relicts cover the higher parts of the plateau area which lies to the south of the Daror depression and north of the Nogal valley (Fig. 2). The mean annual rainfall within this zone is probably very similar to that recorded in the NW and NE Regions, i.e. 136-267 mm, but the altitude at which the zone occurs is somewhat lower. The highest site observed was on the uplifted northern edge of the Shol plateau at 920 m and the lowest was south of Sousciuban at approximately 600 m.

This plateau consists of a limestone deposit (Karkar series, Middle to Upper Eocene). The upper strata have been weathered away to produce a peneplain with a few table-topped remnants. Soil formation on the plateau has clearly been considerable in the past, but degradation of the vegetation cover and subsequent soil erosion have evidently been in progress for a long time. Most of the plateau now bears only a thin layer of truncated soil, and rocky outcrops are common. The remaining soil is a highly calcareous, orange-brown, fine sandy loam or sandy clay loam containing stones; this soil has now been reduced locally to a fine stone mantle. There is naturally a considerable variation in soil texture over the plateau.

Hemming (1966) has already drawn attention to the devastation and degradation to which Acacia bussei open woodland is particularly prone. The eastern parts of this zone in the Bosaso Region probably have the lowest rainfall of any areas where A. bussei is still surviving. The distribution of the vegetation in this zone is very patchy so that the situation closely resembles that which prevails in the areas with vegetation arcs in the NE Region in which run-off from a bare area provides an increased water supply for the next patch of vegetation down the slope.

Throughout this zone A. bussei is by far the dominant tree but over wide areas it is either very sparse or dead. Both the living and dead trees include fine tall specimens occasionally reaching 15 m. The living trees are found in groups in which the most commonly associated woody species is Boscia minimifolia. In the patches of living trees grasses are general, whereas between the patches the soil is almost entirely devoid of cover (Plate 11). The most characteristic grass of the living patches is Andropogon kelleri which clearly indicates that the patches are supported by the run-off from the adjoining bare areas. Other grasses include Dactyloctenium robecchii, Chrysopogon aucheri, Sporobolus ioclados and S. ruspolianus. It is only within these patches that young regenerating Acacia bussei trees are to be seen.

It is clear that under present conditions A. bussei with its superficial root system (Glover, 1951) cannot live without the grasses which arrest run-off and assist the penetration of the water. The converse, however, does not apply and the occasional good patch of grass, for example 8 km south of Gardo, where there is a moderate cover of Chrysopogon aucheri with small amounts of Andropogon kelleri, may be found with no trees either living or dead. Approximately 13 km south of Gardo at an altitude of 690 m in an area of A. bussei, both dead and alive, there are some trees of Cadaba heterotricha and the lower vegetation includes Disperma eremophilum and the grass Sporobolus ruspolianus. These three species are all characteristic of gypseous soils and it would appear that this habitat, in terms of rainfall and altitude, constitutes the transition below which the gypseous soil determines the vegetation and above which climate is the controlling factor.

On the stone-mantle areas that occur on the plateau the vegetation is not concentrated into patches but is generally dispersed more evenly. It is more mixed and does not always include A. bussei. A stone-mantle area 56 km north of Gardo was examined and the trees and shrubs included Acacia mellifera, A. nubica, A. reficiens subsp. misera, A. tortilis, Boscia minimifolia and Euphorbia cuneata. The lower

vegetation consisted mainly of the sub-shrub Vernonia cinerascens and the grasses Dactyloctenium robecchii and Andropogon kelleri. Crossing the plateau north of Gardo there are a number of wide valleys at intervals of 8-11 km. The bottoms of these valleys are generally no more than 30-50 m below the plateau surface. The soil from the slopes has been washed down so that the valleys have been infilled with colluvial and alluvial soils. In one such valley 67 km north of Gardo the soil consisted of a yellowish-red (5 YR 5/8) sandy clay to sandy clay loam with a weak sub-angular blocky structure, and was moderately plastic and non-sticky; as is typical with transported soils no profile development could be seen in the top 30 cm. Owing to the richer vegetation produced by the extra water supply, such valleys have long attracted very heavy grazing and erosion is now serious and increasing. In the next valley 8 km to the south, erosion has reached a more advanced stage and the valley floor now resembles "bad lands" (Plate 12). On the valley floor the vegetation is very sparse, consisting of occasional clumps of the grass Dactylotenium robecchii and occasional Acacia bussei trees. Mature trees may be found in the bottom of some of the eroded gullies, indicating that the erosion is no new phenomenon. The ever decreasing vegetative cover that exists under these conditions of heavy grazing encourages run-off which is now also encouraged by water-tank owners. This is the situation at Boharo, 46 km north of Gardo, where 9 or 10 tanks either have been or are being constructed in the valley soil.

Another eroded valley was examined in some detail by the present author in 1959 which was a wetter year. The soil consisted of a calcareous, silty, fine sand. Locally the erosion has reached down to the underlying limestone, where there are stream beds with quite well developed mature trees indicating that here too erosion is no new phenomenon. The species found in or at the edges of the watercourses include Acacia tortilis, Acacia horrida subsp. benadirensis, Cadaba heterotricha, Balanites sp. and Hyphaene reptans. On the gravelly banks small plants were found: Aerva persica, Cymbopogon schoenanthus, Chrysopogon aucheri and Lasiocorys argyrophylla.

Near the watercourse there are eroded areas of shallow soil where numerous small drainage lines form a fine braided network. In one such site 25 species were collected and none seemed to be dominant and there was no detectable sign of competition. The following species were found in an area only 100 m across: Caryophyllaceae gn. nova, Cleome hanburyana, Commicarpus helenae, Commiphora sp. "Ilka 'adeye", Convolvulus littoralis, Diceratella sinuata, Dyschoriste lycioides, Glossonema boveanum subsp. boveanum, Gloriosa aurea, Ipomoea sultana, Jatropha robecchii, Pleuropterantha revoilii, Pterodiscus ruspolii, Pluchea sarcophylla, Reseda telephiifolia, Solanum dubium, Vernonia cinerascens, Zygophyllum hildebrandtii and Z. sp., Cymbopogon schoenanthus, Dactyloctenium robecchii and Sporobolus ruspolianus.

Over the southern part of the Shol plateau to the north of the gypseous area of the Nogal (Fig. 2), there are areas where no Acacia bussei is to be seen. The vegetation consists mainly of poor Dactyloctenium robecchii grassland unevenly distributed, with large bare patches between the better areas. A conspicuous associate is Adenia ballyi, a large spiny succulent up to 1.5 m high which is found thinly scattered over a vast area, extending into the much lower country towards Eil. In its higher levels, it occurs with Acacia bussei and it seems likely, in view of the altitude and estimated rainfall (Fig. 3), that the area of Acacia bussei open woodland south of Gardo formerly extended considerably further to the south-east in the area marked on Fig. 2 as Sub-coastal zone.

8. EVERGREEN SCRUB

There are two known areas of Evergreen scrub in the Bosaso Region and the existence of a third one may be inferred. The largest area lies to the east of the Ahl Meskat and was encountered to the west of the road approximately 20 km south of El Gal at an altitude of 750 m. While no rainfall data are available for this area local information indicated that the rainfall on the east-facing slopes of the Ahl Meskat is considerably higher than on the plains to the east. An estimate has been made and 300-500 mm has been indicated on Fig. 2. Hemming (1966) gives 523 mm as the mean annual rainfall for Sheik in the NW Region, and as Evergreen scrub occurs in the Bosaso Region much lower this seems a reasonable estimate.

This area of Evergreen scrub is characterised by numerous shrubs of Buxus hildebrandtii, but other evergreen species typical of this zone elsewhere were not found at this low altitude, though they may well occur in the higher parts of the zone which were not investigated.

The main species found with Buxus were Acacia edgeworthii, A. horrida subsp. benadirensis, A. mellifera, A. reficiens subsp. misera, A. senegal and Boscia minimifolia. In narrow valleys Buxus is denser and may be found 50-100 m lower in sites where Mimusops angel and Terminalia polycarpa also occur.

The second known occurrence of Evergreen scrub in the Bosaso Region is in the Galgallo area in the eastern extremity of the Ahl Medo. The only pure evergreen vegetation was a narrow strip at 1130 m, but above this there was an exposed plateau with little soil and covered with stones etched by the wind. Here the vegetation is sparse and the low Euphorbia balsamifera subsp. adenensis is dominant with occasional scattered Dracaena schizantha up to 3.5 m.

On the basis of altitude it would appear that 1130 m would be about the lower limit of Evergreen scrub on open sites, but below the oasis evergreens are found in the sheltered incised watercourses down to 680 m. Other evergreens found with Buxus along the watercourse include Azima tetracantha to 1.5 m, Dodonaea viscosa to 2 m and Rhus retinorrhea to 3 m. Trees of Acokanthera schimperi are also found on alluvial banks a few metres from the stream bed. An examination of the vegetation outside these sheltered sites suggests that all areas below the top layer of Buxus, at approximately 1130 m, should be regarded as Sub-coastal zone. In this particular locality there appears to be an unusually wide transition zone. In the lower part of the Evergreen scrub below about 900 m the commonest shrub is Acacia mellifera, one of the species that is also found on the lower margins of the Evergreen scrub to the east of the Ahl Meskat. In the Bosaso Region it appears that A. mellifera holds a transitional status, as at both sites it occurs on the ecotone between Evergreen scrub and the Sub-coastal zone.

As this particular order of succession, that is Evergreen scrub direct to the Sub-coastal zone with no intermediate zones of Acacia etbaica or Acacia bussei open woodland, is found on the east-facing slopes of both the Ahl Medo and the Ahl Meskat it seems likely that it may be due to some special feature such as greater exposure to the the NE monsoon and higher humidities, dews and mists which may enable Buxus to live at much lower altitudes than further west where the whole ecological system is dominated by the main east-west scarp.

The third area in which Evergreen scrub probably occurs is in the Ahl Bari in the NE of the Bosaso Region. According to the maps the highest point is at 1400 m which is 650 m higher than Evergreen scrub was observed on the eastern slopes of the Ahl Meskat.

9. JUNIPERUS FOREST

The higher mountain areas were not visited in either 1959 or 1970 owing to shortage of time. It is, however, possible to give a brief description of their vegetation from the accounts of Professor Scortecci's travels in 1953 and 1959 (Scortecci, 1953–55, 1958, 1959). Above about 1650 m *Juniperus procera*, *Olea africana* and *Dracaena schizantha* are general. Photographs (Scortecci, *loc. cit.*) indicate *Juniperus* forest relicts on the highest plateau, the Uar Medo, at 2100 m. On high exposed plateau sections the trees are sparse and shorter. They are also distorted by the wind. *Barbeya oleoides*, which is also found at the top of the Mait pass (Hemming, 1966) is also recorded. It is interesting to note that, while at this altitude there is only open forest or relict forest, there is continuous *Juniperus* forest in the Ahl Medo, some 130 km to the west. The present author knows of no published account of the Ahl Bari which lies to the east of the Ahl Meskat, but as the maximum recorded height is 1400 m, it is possible that there may be occasional *Juniperus* trees, though true forest is unlikely.

10. HAUD-TYPE MIXED BUSH

Haud-type mixed bush occupies a strip along the southern edge of the NW and NE Regions (Hemming, 1966) and stretches into the south-western part of the Bosaso Region.

In this area there are no rainfall stations but the mean annual rainfall probably lies in the range 100-150 mm. The altitude of this area lies between 600 and 720 m. In the NW and NE Regions the Haud-type mixed bush can be found between 1110 and 600 m, with a mean annual rainfall in the range 300-150 mm. It is therefore clear that this Bosaso section must be regarded as both low and dry on the average standards of this zone.

Hemming (loc. cit.), in attempting to account for the vast area of this mixed bush in Eastern Africa, which stretches southwards for over 1000 km into Kenya, attributed great significance to the absorptive qualities of the soil as indicated by the absence of any incised drainage pattern over many thousands of square kilometres. The present study on the ecology of the Bosaso Region and the peculiarities of the ecological succession in the region have thrown further light on the problem. In the Bosaso Region the Haud-type mixed bush can be regarded as a higher-altitude form of the Sub-coastal zone which lies immediately to the east, thus justifying Glover's designation of this zone as "the Haud sub-type Acacia tree and shrub" (Glover, 1947).

The only section of this zone sampled on this survey was to the south-west of Rabable (8.17 N, 48.18 E) for a distance of approximately 60 km. To the north there is the complex of soil types that belong to the Gypseous areas and there is a transitional area where gypseous soils and vegetation alternate with Haud-type mixed bush.

The reddish loamy sands that occur in this zone further to the west do not extend into this portion of the Bosaso Region; the soils are generally finer and less red in colour and may be classified as limestone-derived soil, either residual or locally transported. In texture they are sandy loams but there are also considerable areas of gravelly stone mantles. These soils are more prone to erosion, and one section of an abandoned road was eroded to bed rock at 1.5 m.

Approximately 10 km south-west of Rabable, in a marginal example of Haud-type vegetation, species of Acacia were dominant: Acacia mellifera, A. nubica, A. reficiens subsp. misera and A. tortilis. Commiphora sp. was also present but in very small numbers. Grewia penicillata and G. tenax were plentiful. Another characteristic species was Sesamothamnus busseanus which is also very common on the redder sandy soils in the Mudugh Region to the south.

Another indication of the transitional nature of this section of Haud-type mixed bush is that it is not flat although it is typically a plains community. In this transitional zone dense groves of Euphorbia robecchii trees are common at the edges of the valleys, which suggests that the soils are somewhat gypseous. They are badly eroded and support Acacia tortilis in some of the deep gullies.

One extremely rich section of Haud-type mixed bush was seen close to the extreme south-east corner of the NE Region. The soil was not the reddish loamy sand more typical of the western Haud, but it clearly absorbed water readily as there were no incised drainage lines even at the foot of a limestone hill from which there must have been considerable run-off. The vegetation was very mixed and the following species were noted: Acacia horrida subsp. benadirensis, A. senegal, Boscia minimifolia, Commiphora spp., Cordia sinensis, Dalbergia commiphoroides, Grewia penicillata, G. Tenax and Gyrocarpus hababensis. This last species was the tallest tree and was very common.

A feature of this Haud-type mixed bush is the switch in the dominant species over quite short distances, so that the whole area is a vast, complex, ever-changing mozaic. It was, for example, noted that a few kilometres to the west the dominant species was Terminalia orbicularis. In this area Commiphora spp. are very important while in other areas numerous species of Acacia contribute most of the shrub and low-tree layer growing to 4-5 m and Commiphora is relatively unimportant. It is probable that Acacia and Commiphora are the most important genera in this Haud-type vegetation, but its mixed nature is nevertheless its main characteristic.

There was a good mixture of grass species with much bare ground. A large proportion of the grasses were annuals, suggesting that the grass layer has been altered by grazing. This is somewhat surprising in such apparently lush and unspoiled bush, but in this vegetation where woody shrubs are so important the potential grass yield is relatively low; consequently even quite light grazing is enough to have a marked effect upon grass layer. Within the whole area there are occasional open grass plains and in these the situation is entirely different. The commonest generally distributed perennial grass is Chrysopogon aucheri but it only occurs in small amounts. The largest perennial grass is Andropogon kelleri growing in groups of large clumps locally up to 2 m in height. Such clumps indicate additional water and very local sheet flow and ponding. The annual grasses include several species of Aristida, including A. kelleri and A. papposa, also Dactyloctenium scindicum and Tetrapogon cenchriformis.

Hemming (1966) stated that "the reduction in rainfall in the Haud from East to West is paralleled in a reduction in height and density of the mixed Acacia Commiphora bush". When this statement was made the author had never seen the particular unspoiled site described above. Its existence in the drier and lower easterly part of the Haud would seem partially to invalidate this view. It is, however, true as a generalisation and was indeed observed over a vast area of heavily grazed bush, but it can only be an accurate statement under equal conditions of grazing or protection. The discovery of this particular site demonstrates forcibly the effect of grazing pressure and further suggests that the Haud-type mixed bush, which has long been regarded as a relatively unaltered zone of rich vegetation, forming the country's finest grazing, is in fact considerably altered and its supervision and protection from serious overgrazing are essential if it is not to be destroyed in the same manner as has been the Acacia bussei open woodland to the north.

It is interesting to speculate as to why this particular area has been preserved in such good condition. The only plausible hypotheses appear to be: that owing to its exact geographical position it is not on a stock migration route; or that in former more unsettled times it was an area of tribal dispute; or that the low rainfall did not fill enough "ballehs" or seasonal ponds for the stock to remain for as long in this area as further west. Whatever is the true cause, it is clear that the effect of lower rainfall is more than offset by the effect of less grazing.

11. GYPSEOUS AREAS

Within the Bosaso Region there are two major areas where the vegetation is determined by the gypseous and sometimes saline nature of the soil. The northern section constitutes the southern portion of the Daror depression and the other major gypseous area lies in the Nogal valley. There is also a smaller outcrop around Gardol.

11.1 THE NOGAL

The greater part of the gypseous area of the Nogal valley lies within the NE Region to the west of the Bosaso Region. In Fig. 2, the eastern limits of gypseous areas have been taken from the geological map (AGIP, 1957).

The anhydrite bed of the Nogal valley has, at the surface, generally been altered to gypsum and has given rise to gypseous soils. Along the southern side of the Nogal there is a broken line of low hills composed of thin strata of anhydrite, limestone and chert.

The basic soil consists of a gypseous silty clay which, when dry, is readily pulverised by stock and vehicles and is then eroded by both wind and water. The reduced vegetation cover resulting from overgrazing also encourages erosion. The soil has largely been eroded away from residual sites and has been redeposited elsewhere. The nature of the vegetation in any site depends mainly upon the depth of soil above the gypsum and the drainage. These gypseous soils, when deep enough and well watered, support a moderate vegetation cover but in areas where the soil is badly eroded the vegetation is generally sparse and halophytic. Over wide areas, particularly in the east, the gypseous soils support grassland similar to the lowland plains of the Sub-coastal zone. Sporobolus ruspolianus is the characteristic species of these soils and it is found wherever soil remains. Chrysopogon aucheri is also found in smaller amounts on the less eroded sites. The evergreen Cadaba mirabilis on fine soils is usually an indicator of gypsum.

One characteristic of these anhydrite areas is the presence of sink-holes. They often occur in a line across an almost level plain and support good-sized trees, suggesting underground water. At the edges of individual sink-holes Ficus salicifolia is characteristic and Acacia tortilis trees form a broken line connecting up a series of sink-holes.

The deeper, less eroded, gypseous soils support an open type of shrubby vegetation of which characteristic species are Cadaba heterotricha, Commiphora spp. and Salvadora persica, with occasional groups of Euphorbia robecchii. Between these shrubs and low trees there is perennial clumpy grassland of Chrysopogon aucheri, which is now restricted to relicts that have escaped overgrazing and subsequent degradation.

The next degradation stage in the Nogal is found in areas from which either practically all the soil has been removed to reveal the underlying gypsum, or where a little saline soil remains and secondary gypsum is visible on the surface. The former type generally supports less halophytic vegetation than the latter but this is more marked to the west in the NE Region. In the Bosaso section of the Nogal both types carry a regularly spaced pattern of Sevada schimperi, a low succulent halophyte 15-25 cm high and 30 cm wide and the distance between plants is 0.5-2 m. This is the Lagenantha nogalensis association of Gilliland (1952).

Occasionally, within the regular pattern of Sevada schimperi, individual plants are replaced by Atriplex coriacea, Ipomoea sultani, Kelleronia sp., Launaea spinosa, Limonium axillare, Portulaca sp. aff. wightiana, Momordica sessilifolia and Zygophyllum sp. These species are found in areas where the salinity is less extreme and are, for example, common within lines of Acacia tortilis on anhydrite plains.

In addition to this degradation series there is a reverse series where gypseous silty clay soils have been redeposited. Where deposition occurs today the area is usually marked by numerous shallow drainage lines and runnels which support Disperma eremophilum. Further east there are large deposits of such soil which must be regarded as an ancient alluvial deposit. In such areas well spaced low bushes of Cadaba mirabilis are characteristic.

A gypseous plain on which Sevada is dominant is cut by a tug at Bihen just west of the regional boundary at 08.25 N. The tug is incised into the plain to a depth of 6-12 m and has an irregular rocky bed in which pools remain throughout the dry season. These pools support Chara socotrensis with Scirpus maritimus near the edges. Around the pools there is Paspalum vaginatum and Enicostema axillare. At the edge of this zone there are occasional clumps of Sporobolus consimilis and still further from the pools there is an ill-defined zone of Tamarix nilotica bushes.

Away from the influence of the pools the tug bed is largely bare. Succulent Zygophyllum sp. and Pulicaria sp. are the commonest species but even these are widely spaced; associated species include Capparis cartilaginea, Limonium axillare, Serra incana and Merremia sp. At the edges of the tug bed in loose talus there are small Acacia tortilis trees and bushes of Salvadora persica.

11.2 MELEDEN AREA

North of the Carcar mountains and forming the southern part of the Daror depression there is a wide area of anhydrite deposits. Over most of the area the anhydrite is hidden by soil, which is generally fine and silty, easily pulverised by vehicles and then eroded. The grass cover on these areas with soil is generally sparse and heavily overgrazed. Much of the area has an overlying layer of alluvial gravel, and stone mantles are common. The vegetation in this area shows little evidence of gypsum in the soil; it is typical of the Daror depression, in which the main grass is Dactyloctenium robecchii, and there are scattered trees and shrubs of Acacia tortilis, A. horrida subsp. benadirensis, A. edgeworthii and Boscia minimifolia. A species which is also found and is more indicative of gypsum soils is Cadaba heterotricha. Along the south margin of this area the gypsum is exposed in low stepped hills similar to those at Las Anod (Hemming, 1966). South-east of Meleden the soils are very eroded and halophytic plants such as Sevada schimperi are dominant. Unpalatable composites are also common. Within such areas there are occasional low Acacia reficiens subsp. misera.

Near the village of Meleden there are signs of extensive and prolonged flooding, though this area was very dry when seen in November 1970. The most deeply flooded area supports a dense stand of Indigofera oblongifolia and Salsola sp. which may attain 2 m in height. In the slightly less flooded area there is Tamarix nilotica which is a salt-tolerant species, but it is not typical of areas of very prolonged flooding; in this habitat its growth is restricted to a few metres and no well developed trees were seen. Other species in this area are Cadaba glandulosa, Serra incana and Indigofera sp.

North of Meleden there is a transition zone to the Daror-type grassland. Characteristic tall plants to 2 m or more are Acacia sarcophylla and Calotropis procera. Cadaba mirabilis is typical of gypseous soils and Serra incana and several unidentified grasses are the result of the extra run-off. To judge from the grass cover in November 1970, when the whole area was dry and very heavily overgrazed, this transition zone could probably produce a plentiful yield of grass during a wetter year.

11.3 GARDO AREA

The town of Gardo is situated on an outcrop of gypsum and anhydrite and in the surrounding area there are gypseous soils on plains and in valleys with additional water supply.

In the area close to the town there is very heavy overgrazing, and unpalatable genera like Ipomoea, Farsetia and Solanum are dominant.

In a nearby valley which receives additional run-off Disperma eremophilum is dominant. There are widely spaced Acacia tortilis trees and some grass (Cynodon). On the plains, where the effect of the gypsum is less marked, there are fine soils with Sporobolus ruspolianus, S. ioclados with some Disperma eremophilum, and close to the limestone hills groups of Euphorbia robecchii to 3-4 m are characteristic.

12. DISCUSSION

In this account the vegetation of the Bosaso Region has been described under the system of classification that was erected to suit the North-west and North-east Regions, which were formerly together known as the Northern Region (Hemming, 1966). This has been done in order that the whole of the three regions, covering some 250,000 km^2, may be considered as a single unit.

The ecology of the NW and NE Regions is dominated by the basic physiography by which the area is divided into three zones: coastal plain, escarpment and plateau. In fact the basic succession is apparently controlled by altitude which accounts for all the zones except two, the Haud-type mixed bush and the Gypseous areas. While the latter zone can satisfactorily be dismissed as edaphically controlled, the former should not be so dismissed, though Hemming (loc. cit.) attributed great importance to adaphic factors. The present study suggests that, while the vegetation of the NW and NE Regions increases from north to south with increasing altitude and rainfall, the vegetation of the Bosaso Region and probably that of the Mudugh Region increases from ESE to WNW. The fact that the succession under these two systems is different is no reason for surprise. The area under discussion is very large, some 900 km along a line of latitude, so a change in the species content of zones, or even in the dominant species, is to be expected. Field evidence suggests that the climate of the Bosaso Region is also different and that it is, in effect, moister than the mean annual rainfall figures would lead one to expect. In the Bosaso Region the ESE - WNW succession appears to be a simpler one involving fewer ecological zones. In the north-east the vegetation of the Sub-coastal zone becomes gradually richer until it changes to Evergreen scrub on the east-facing slopes of the Ahl Medo, the Ahl Meskat and probably the Ahl Bari. In the south the sub-coastal vegetation improves also gradually until it becomes Haud-type mixed bush. It is only in the central area of the region that the ecological succession is the same as in the regions to the west, that is from the Sub-coastal zone to Acacia bussei open woodland, but this occurs only in areas which are contiguous with the same vegetation further west. This succession in the Bosaso Region may therefore be regarded as the most easterly limit of the western succession.

In Fig. 4, the geographical distribution of the different successions is indicated.

As the Haud-type mixed bush is the most southerly zone in the NW and NE Regions, one would also expect the effect of the north-south succession controlled by the east-west scarp to be at a minimum. Haud-type vegetation stretches southwards far over 1000 km more or less parallel to the coast of the Indian Ocean, which again points to the relationship between this zone and the ESE - WNW succession.

The heavy dews and thick mists, together with observations on the occurrence of Boswellia carteri, particularly at low altitudes, all suggest that the climate, especially in relation to humidity, is markedly different from that in the regions to the west. Owing to the poor distribution of rainfall stations and the sparse records available it is not possible to calculate the relationship between increasing altitude and increasing rainfall, but it seems quite likely that the different successions could be related to different altitude-rainfall relationships in the same way as has been established in Kenya (Trapnell & Griffiths, 1960). The fact that Evergreen scrub is found on the eastern slopes of Ahl Meskat at 750 m, which is about 700 m lower than in the regions to the west except in sheltered gullies, certainly suggests a different altitude-rainfall relationship.

The status of Acacia mellifera in the northern part of the region is difficult to assess. In the NW and NE Regions it is a species mainly characteristic of the wetter areas of the western Haud. It is not typical of the Sub-coastal zone, but in the Bosaso Region its appearance in the higher and wetter sections of this zone on east-facing slopes provides evidence, at least on the Ahl Medo and the Ahl Meskat, of the proximity of Evergreen scrub. It is never sufficiently plentiful or extensive to warrant the erection of a separate zone, but it is a useful indicator in the field.

In the ecological classification used here the Sub-coastal zone is by far the largest (Fig. 2), and it includes large areas of edaphically controlled, treeless, grassland plains. In most such areas the grass cover is very low, but owing to the extremely flat nature of these areas erosion of the gully type is a minor problem. When these areas are considered in relation to grazing, it is clear that in general, while the stony areas can provide browse species, the plains must provide the grass. Though the vegetation cover is low the number of grass plants is high enough to suggest that, given some protection, these areas would improve rapidly and must therefore be regarded as potentially very valuable grasslands despite their current low yield.

Although there are only relatively few important grass species involved, the ecology of these plains varies considerably with respect to rainfall, run-off from adjacent stony areas, soil depth, soil texture and water-holding capacity. As these plains represent the main grass-production areas of the Bosaso Region more detailed ecological investigations are required.

An examination of Fig. 1 shows the sparse network of routes along which observations were made, and upon which this report is based. The most serious gap in this survey lies within the triangle Gardo-Eil-Bender Beila, an area of some 15000 km^2 with no major vehicle routes. The ecological nature and forage-production potential of this and other vast areas must therefore remain a matter for conjecture until a detailed survey can be undertaken. Owing to the inaccessibility of large areas extensive use of airphoto interpretation will be necessary as has been done in the southern part of the Republic (FAO, 1968).

REFERENCES

AGIP. 1957 Carta geologica della Somalia e dell'Ogaden. AGIP Mineraria - Consiglio Nazionale delle Ricerche, 8 sheets at 1/500,000.

Azzaroli, A. 1957 Missions geologica in Mijurtina, Ricerca scient. 27:301-346

FAO 1968 Agricultural and water surveys, Somalia, Final report. Vol. IV, Livestock and crop production. FAO/SF: 36/Som. 173 pp.

Gilliland, H.B. 1952 The vegetation of eastern British Somaliland. J. Ecol. 40:91-124.

Glover, P.E. 1947 A further contribution to the ecology of western British Somaliland, 2(2). (Unpublished report at the Agricultural Department Library, Hargeisa.)

Glover, P.E. 1951 The root system of some British Somaliland plants. IV. E. Afr. agric. J. 17:38-50.

Griffiths, J.F. & Hemming, C.F. 1963 A rainfall map of eastern Africa and southern Arabia. Mem. E. Afr. met. Dep. 3(10) 44 pp.

Hemming, C.F. 1961 The ecology of the coastal area of northern Eritrea. J. Ecol. 49:55-78.

Hemming, C.F. 1965 Vegetation arcs in Somaliland. J. Ecol. 53:57-67

Hemming, C.F. 1966 The vegetation of the northern region of the Somali Republic. Proc. Linn. Soc. Lond. 177:173-250

Hemming, C.F. & Trapnell, C.G. 1957 A reconnaissance classification of the soils of the South Turkana desert. J. Soil Sci. 8:167-183.

Hunt, J.A. 1951 A general survey of the Somaliland Protectorate 1944-1950. London; Crown Agents 203 pp., 42 figs.

Macfadyen, W.A. 1933 The geology of British Somaliland, Part I. Somaliland Government 87 pp. 4 pls.

Mitchell, J.M. Jr. 1963 On the world-wide pattern of secular temperature change. Arid Zone Res. 20:161-181.

OUP 1959 Vegetation map of Africa south of the tropic of Cancer. Published by Oxford University Press on behalf of l'Association pour l'Etude Taxonomique de la Flore d'Afrique Tropicale.

Pichi-Sermolli, R.E.G. 1957 Una carta geobotanica dell'Africa Orientale (Eritrea, Etiopia, Somalia). Webbia 13:15-132.

Scortecci, G. 1953-55 Viaggio di esplorazione biologica sulle montagne della Migiurtina. Boll. Musei Ist. biol. Univ. Genova 25:43-105.

Scortecci, G. 1958 Esplorazione della Ahl Mescat occidentale e orientale. Boll. Soc. geogr. ital. 415:1-34.

Scortecci, G. Esplorazione delle montagne Migiurtina. Atti Accad. ligura 15, 23 pp. 1959

SOMALILAND OIL EXPLORATION COMPANY A geological reconnaissance of the sedimentary 1954 deposits of the Protectorate of British Somaliland. London; Crown Agents.

Trapnell, C. G. & Griffiths, J.F. The rainfall-altitude relation and its ecolo- 1960 gical significance in Kenya. E. Afr. agric. J. 25:207-213.

Vesey-Fitzgerald, D.F. Vegetation of the Red Sea coast south of Jedda, Saudi 1955 Arabia. J. Ecol. 43:477-489.

Vesey-Fitzgerald, D.F. Vegetation of the Red Sea coast north of Jedda, Saudi 1957 Arabia. J. Ecol. 45:547-572.

A P P E N D I X - I

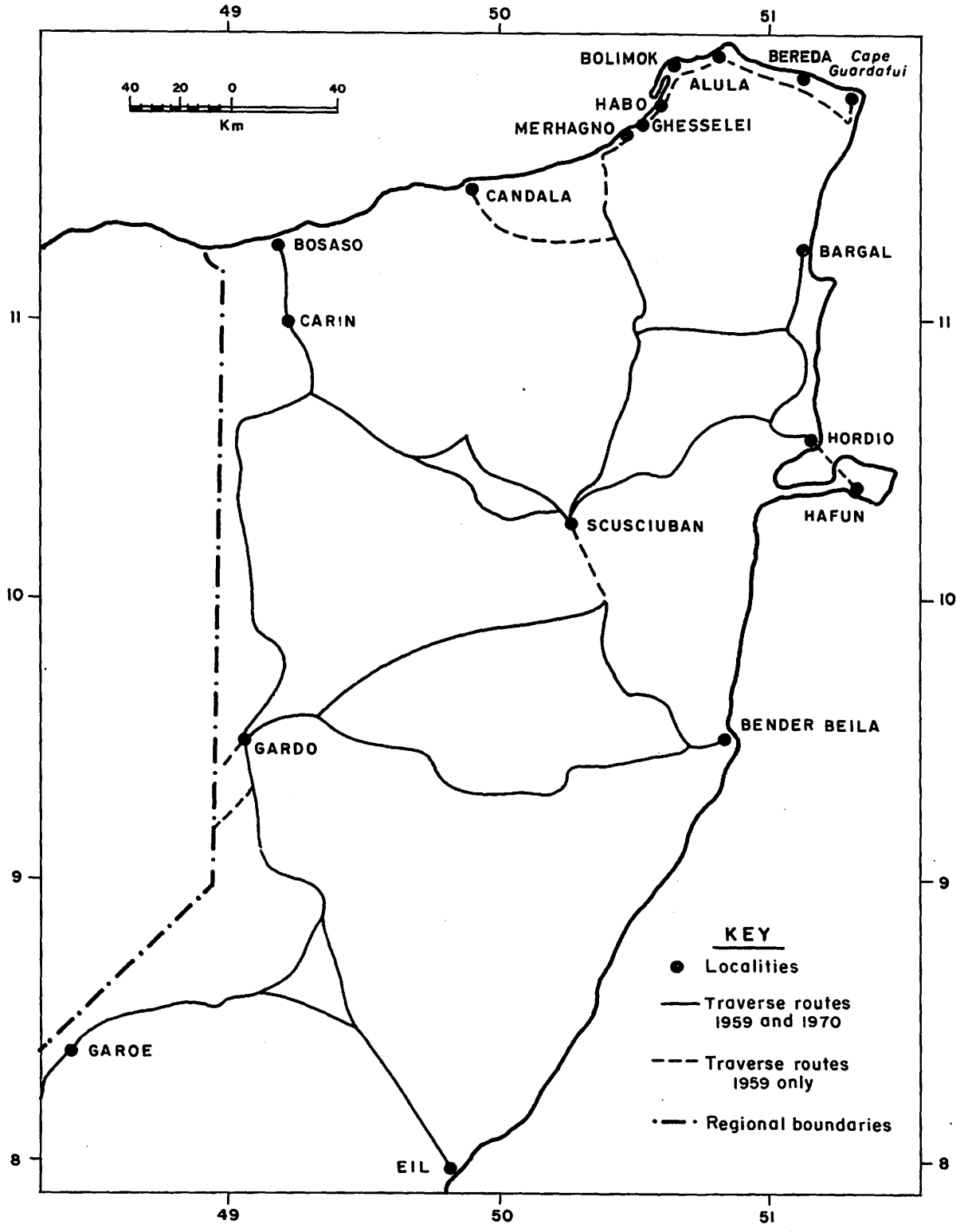

Fig. 1. Outline map of the Bosaso Region showing the routes covered during reconnaissance trips in 1959 and 1970.

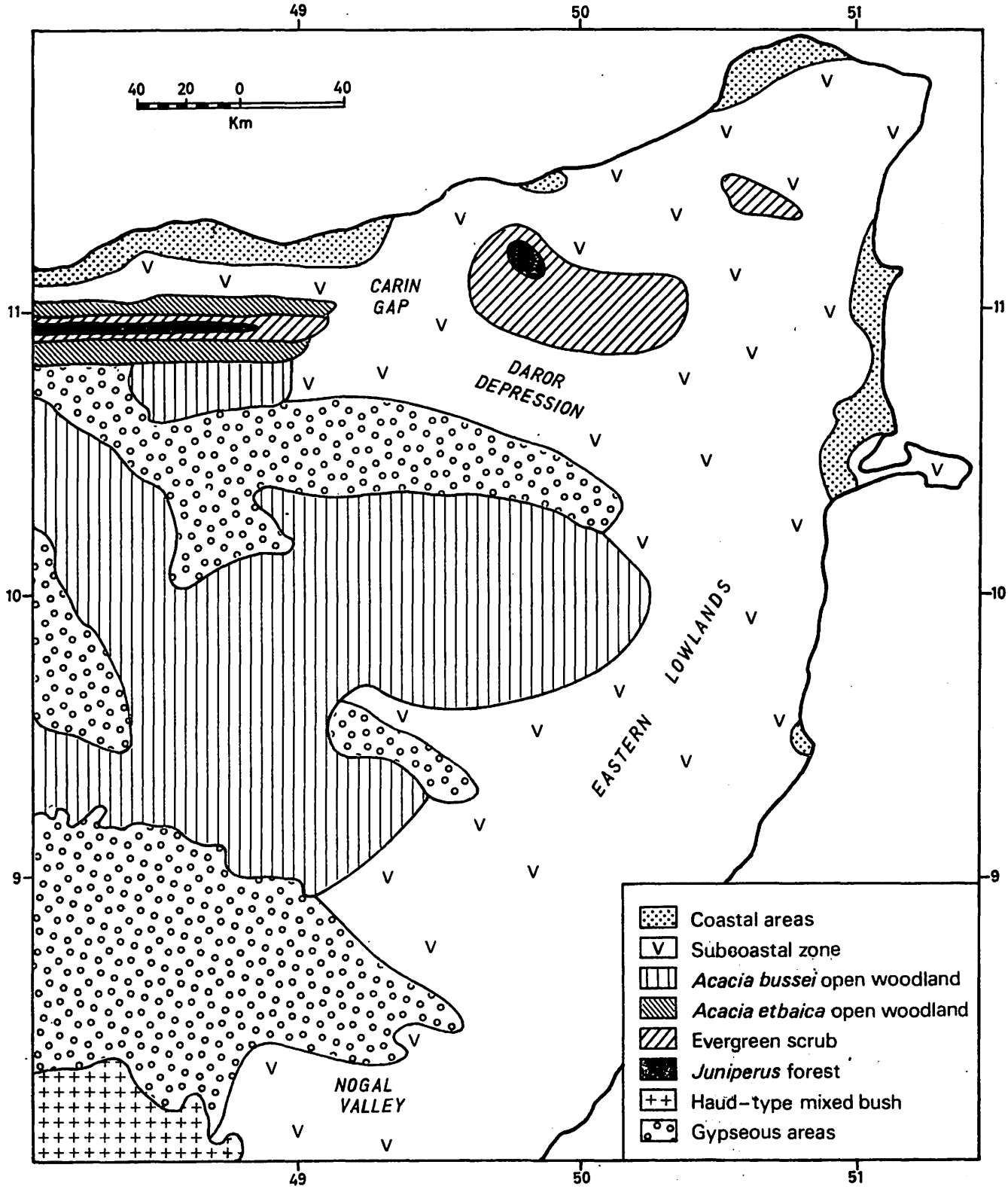

Fig. 2. Generalized map of the vegetation zones of the Bosaso Region.

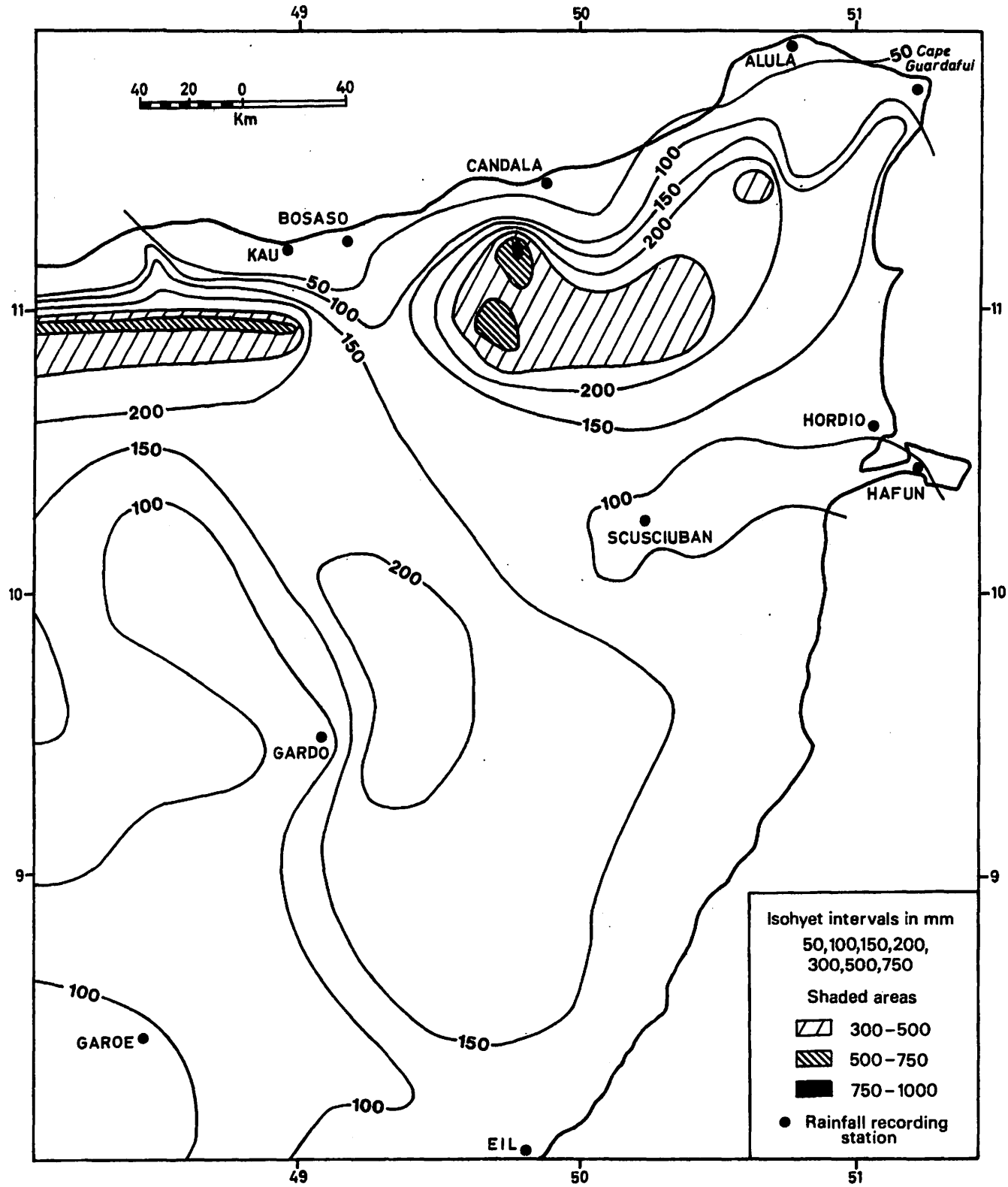

Fig. 3. Rainfall map of the Bosaso Region

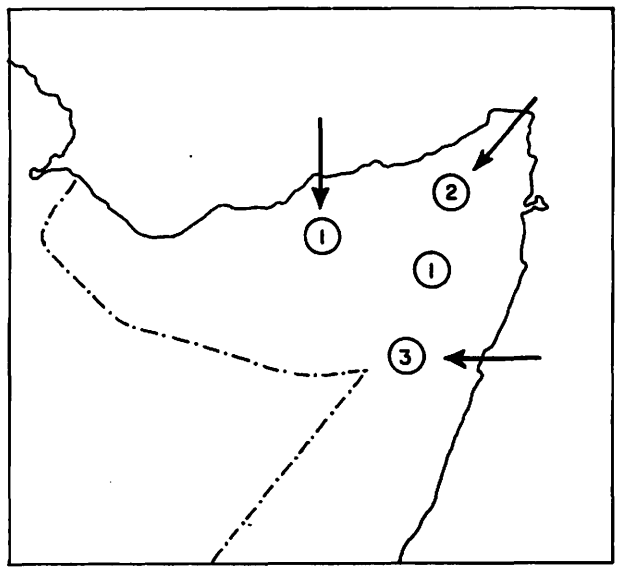

Fig. 4. Map presenting the geographical distribution of the different ecological successions in the Bosaso Region

1. The western succession: .

   Coastal area
   Sub-coastal zone
   A. bussei open woodland
   A. etbaica open woodland
   Evergreen scrub

2. The north-east succession:

   Coastal area
   Sub-coastal zone
   Evergreen scrub

3. The south-east succession:

   Coastal area
   Sub-coastal zone
   Haud-type mixed bush

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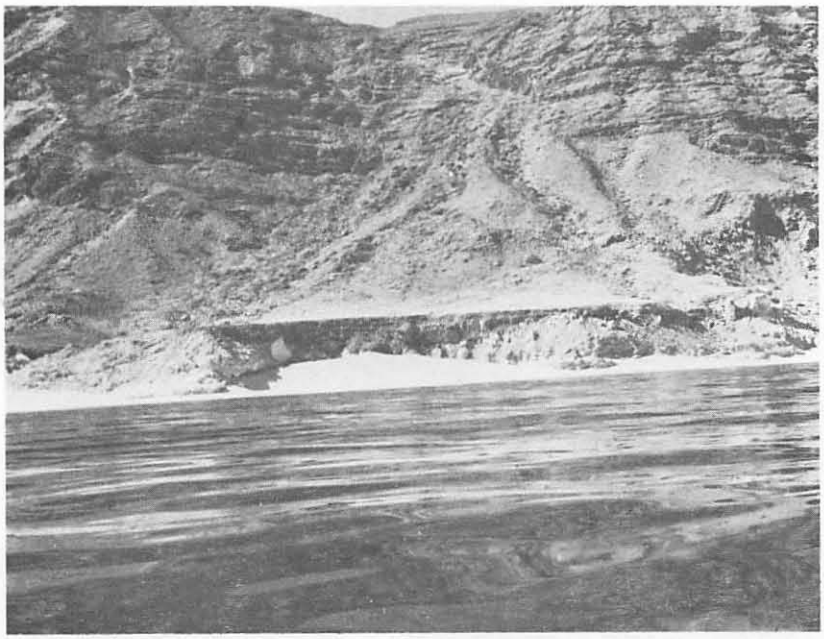

Plate 1. A relict of the former coastal plain on the north coast near the tip of the Somali peninsula.

Plate 2. An area of dense Acacia edgeworthii and Sclerostephane adenophora on the coastal plain near Bargal.

Plate 3. The estuary of Tug Galwein. The vegetation on the highly saline banks is almost pure Tamarix nilotica. Wind-blown sand on the slopes supports Salvadora persica.

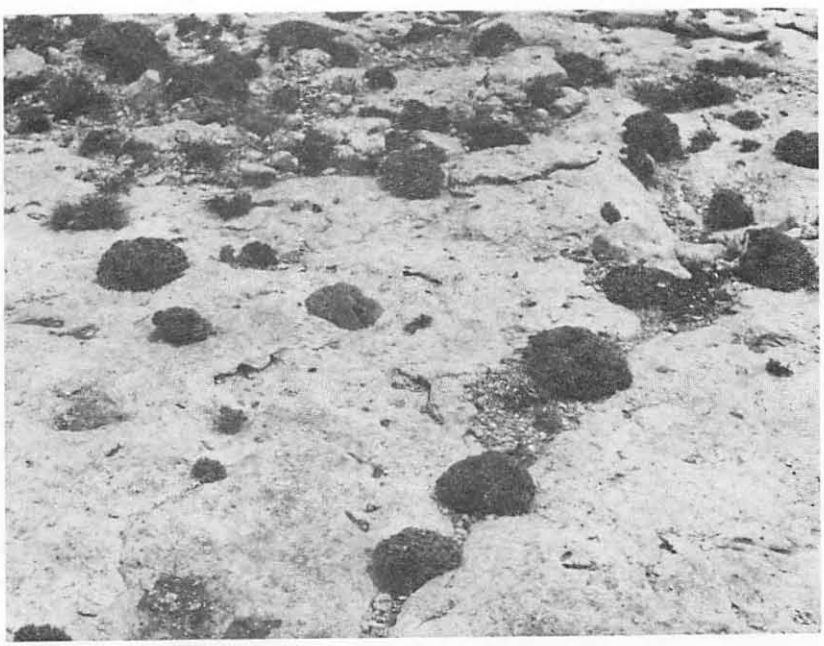

Plate 4. Dense cushion-like wind-resistant plants on the top of the limestone cliffs overlooking the Nogal valley at Eil. The dark-coloured plants growing in the crack are Pulicaria sp.

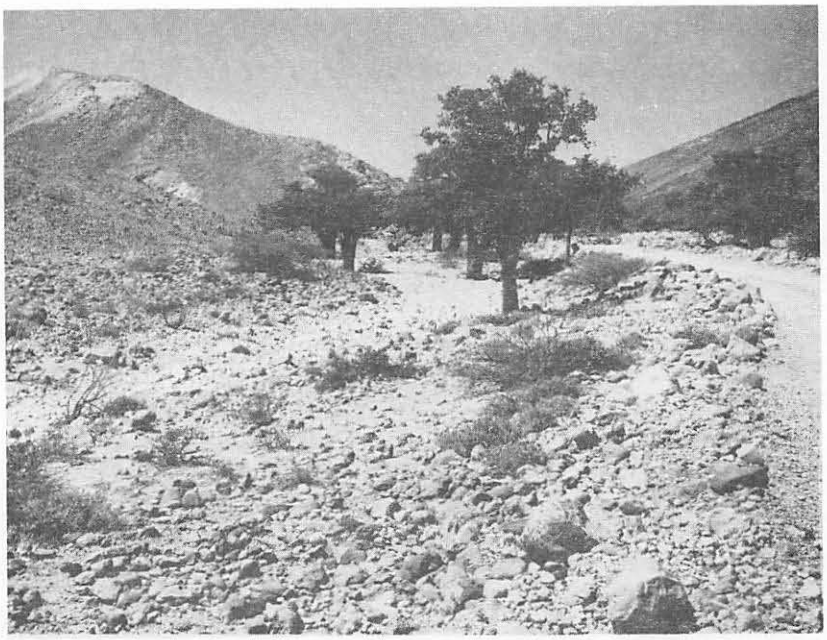

Plate 5. Small stony tug in the Carin gap with an intermittent line of mature Mimusops angel.

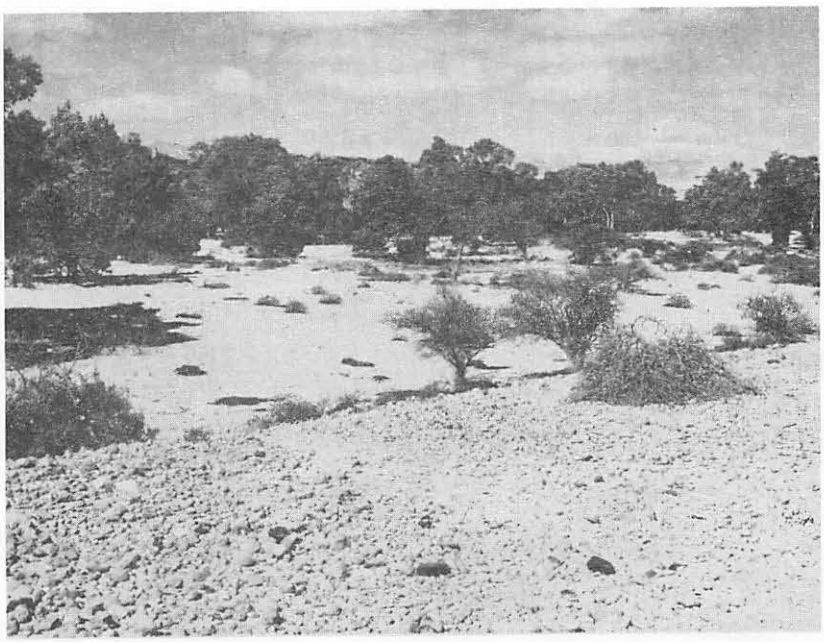

Plate 6. A wide section of Tug Yalho in the Carin gap with numerous large Conocarpus lancifolius.

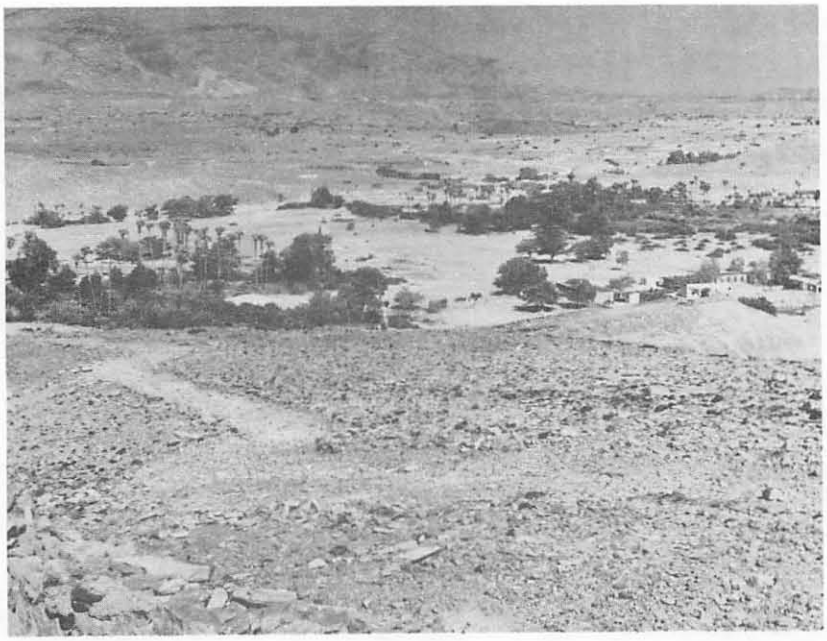

Plate 7. The oasis of Carin seen from the edge of the Carin gap.

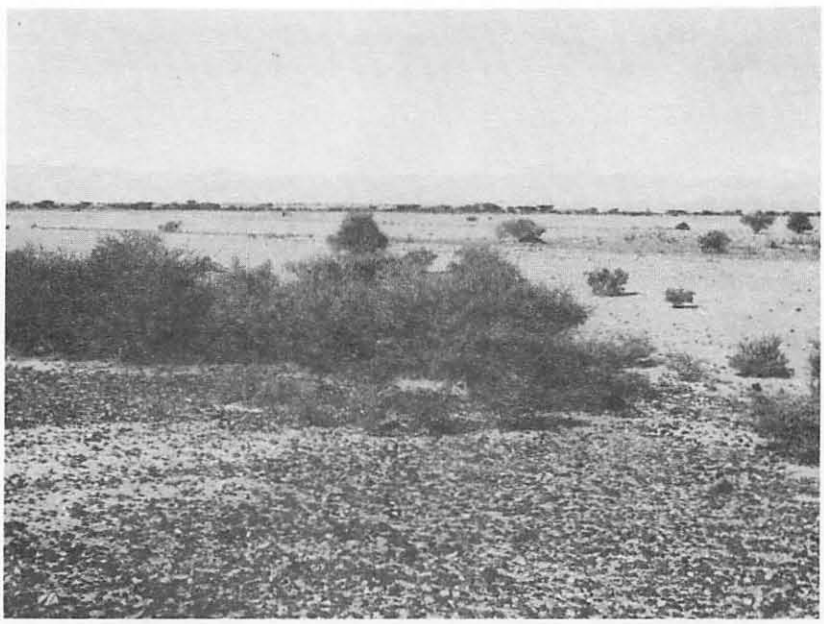

Plate 8. A shallow depression of fine colluvial soil derived from the surrounding stone mantles. In the central wettest area traces of Chrysopogon aucheri remain.

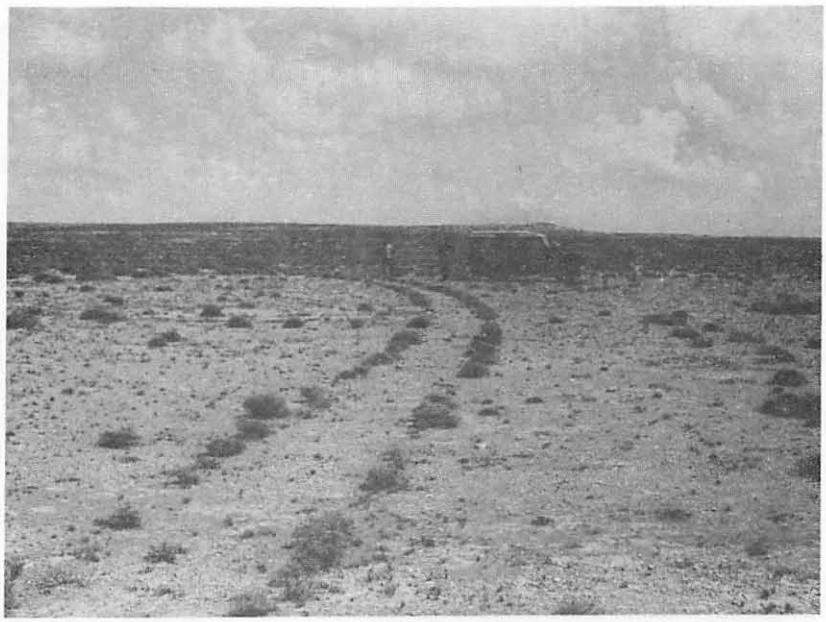

Plate 9. Old tracks colonised by Dactyloctenium robecchii in a bare section of the Eastern Lowlands.

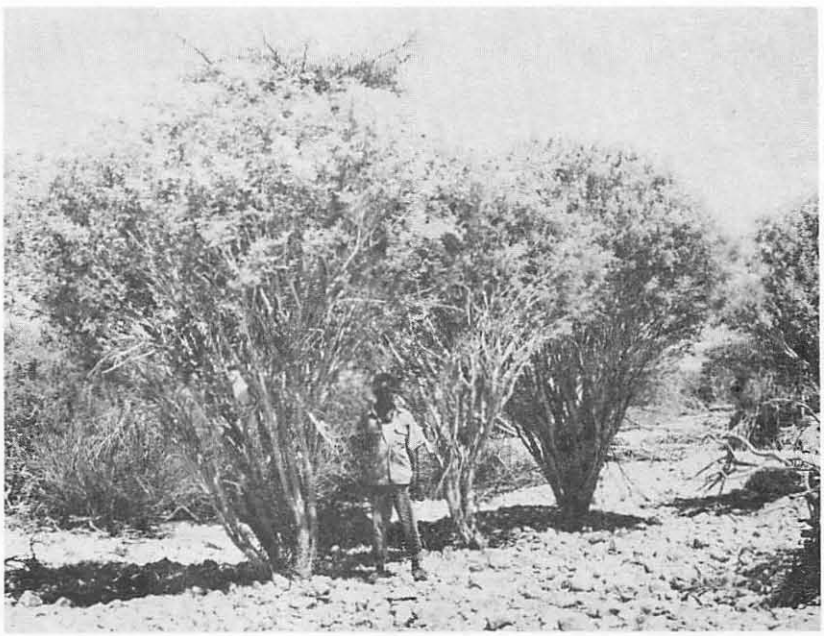

Plate 10. Acacia ankokib, a common species in the tugs in the north-east part of the region.

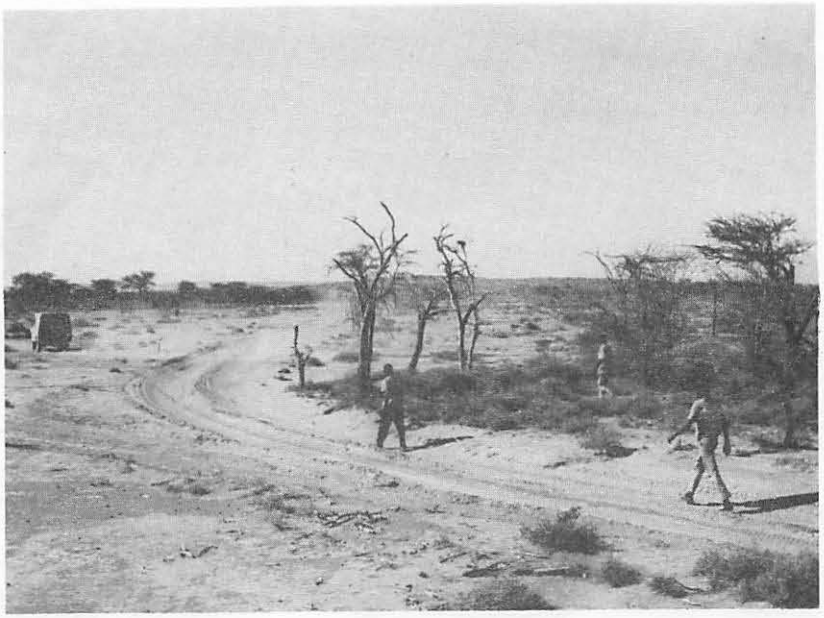

Plate 11. *Acacia bussei* open woodland. A few trees remain in isolated patches of *Andropogon kelleri*. Most of the plateau is now completely bare.

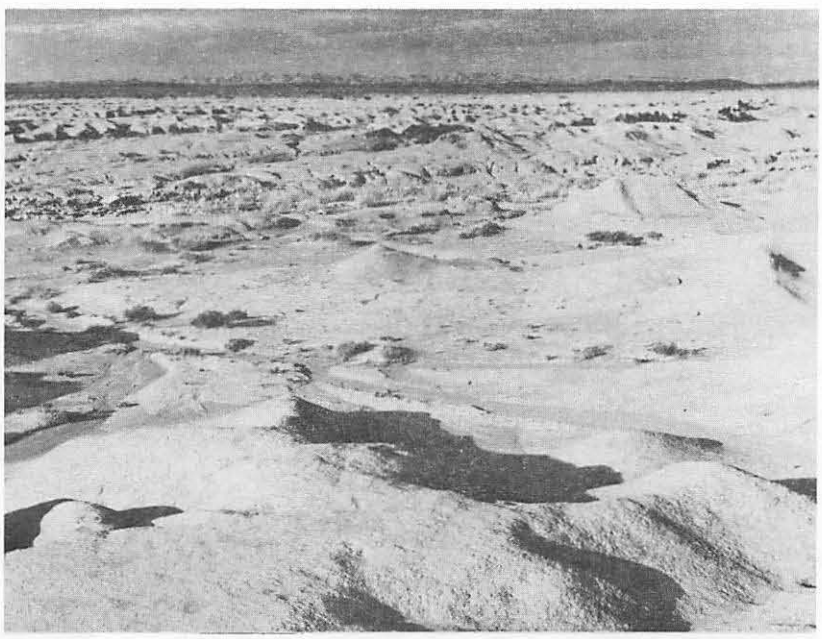

Plate 12. Severe erosion produced by prolonged over-grazing on colluvial valley soils within the zone of *Acacia bussei* open woodland.