QUEENSLAND

BUREAU OF INVESTIGATION

TECHNICAL BULLETIN

No. 5

THE SOILS OF THE INGLEWOOD-TALWOOD-TARA-GLENMORGAN REGION, QUEENSLAND.

by

R. F. Isbell

PREPARED BY THE
BUREAU OF INVESTIGATION, DEPARTMENT OF PUBLIC LANDS,
BRISBANE, QUEENSLAND, 1957.

ISSUED BY DIRECTION OF
HONOURABLE A. G. MÜLLER, MINISTER FOR PUBLIC LANDS
AND IRRIGATION.

By Authority: A. H. TUCKER, Government Printer, Brisbane.

Queensland Government Technical Report

For information about this report contact soils@qld.gov.au

QUEENSLAND

BUREAU OF INVESTIGATION

TECHNICAL BULLETIN

No. 5

THE SOILS OF THE INGLEWOOD-TALWOOD-TARA-GLENMORGAN REGION, QUEENSLAND.

by

R. F. Isbell

PREPARED BY THE
BUREAU OF INVESTIGATION, DEPARTMENT OF PUBLIC LANDS,
BRISBANE, QUEENSLAND, 1957.

ISSUED BY DIRECTION OF
HONOURABLE A. G. MÜLLER, MINISTER FOR PUBLIC LANDS
AND IRRIGATION.

By Authority: A. H. TUCKER, Government Printer, Brisbane.

Bureau of Investigation.

CHAIRMAN:

J. A. HOLT, B.E., M.I.E. Aust., Co-ordinator-General of Public Works.

DEPUTY CHAIRMAN:

A. F. BELL, B.Sc. (Q'ld.), M.S. (Calif.), D.I.C. (Lond.), A.A.C.I., Under Secretary, Department of Agriculture and Stock.

MEMBERS:

W. H. R. NIMMO, M.C.E., M.I.C.E., M. Am. Soc. C.E., M.I.E. Aust.

J. J. BERGIN, Chairman, Land Administration Board.

W. A. T. SUMMERVILLE, D.Sc. (Q'ld.) Assistant Under Secretary (Technical), Department of Agriculture and Stock.

CONTENTS.

MAPS.

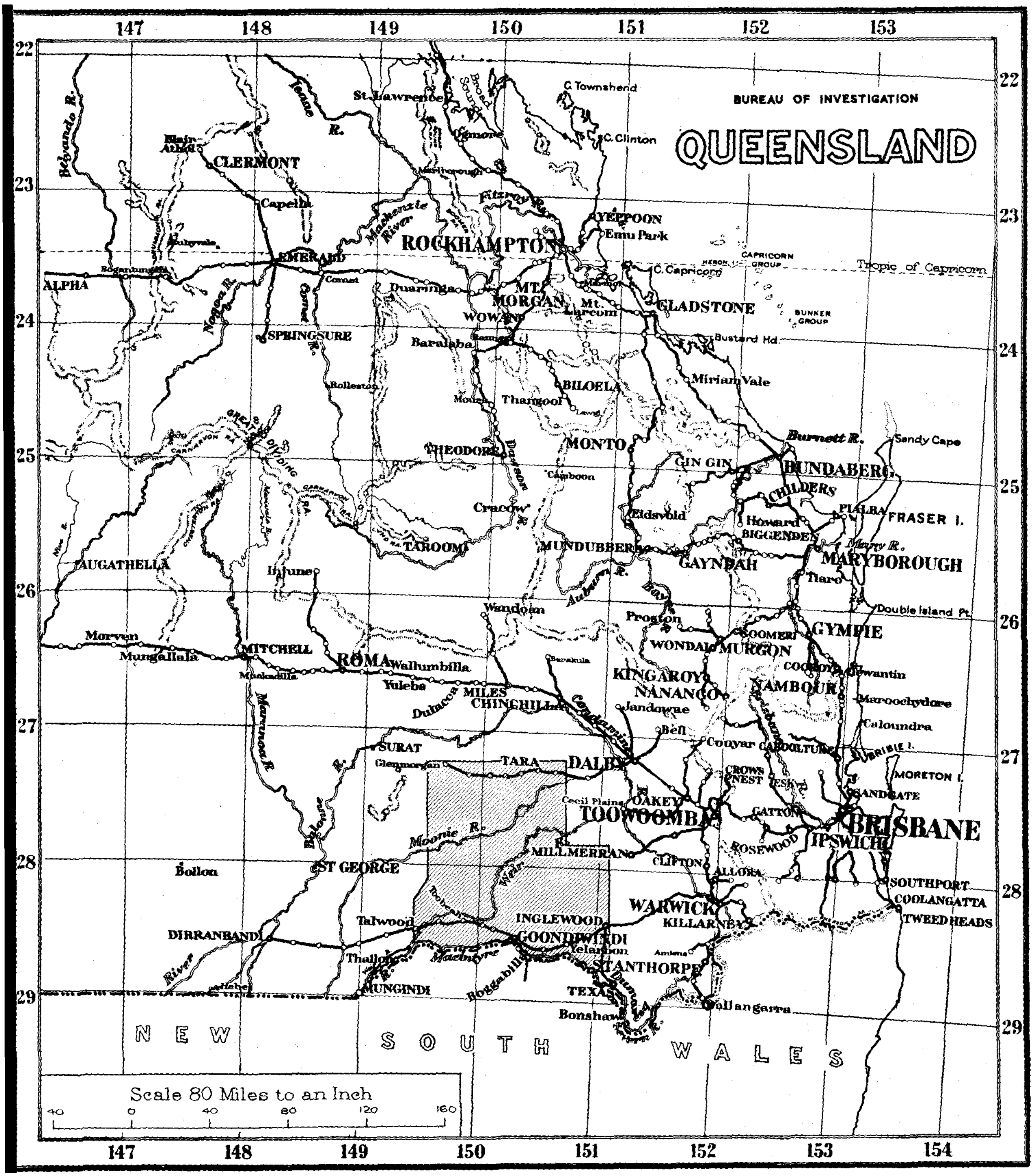

Fig. 1. Locality Map.

SUMMARY.

A fairly comprehensive reconnaissance soil survey has been made of an area of approximately 8,500 square miles in southern Queensland, extending northwards from the State border. This region lies within the 20in.–25 in. rainfall zone with approximately two-thirds of the rainfall occurring during the hot summer months. The winters are normally fine and mild although frosts are common. Rainfall, temperature, and humidity data for available stations are tabled and the incidence and reliability of the rainfall in relation to agriculture is discussed.

The region forms part of the south-eastern corner of the Queensland portion of the Great Artesian Basin and is not a naturally distinct physiographic or geological province. The greater part of the region is essentially a plainland, although some areas are interrupted by low lateritic residual scarps and mesas. The Palaeozoic basement rocks of the Artesian Basin outcrop in the extreme east and unconformably resting on these are several gently westerly dipping Mesozoic formations. However, in most areas these are obscured by Tertiary lateritic developments and Quaternary deposits.

Much of the region possesses a dense timber cover, brigalow and belah forests being particularly widespread. The vegetation is discussed in terms of the major communities present but a detailed ecological or botanical survey has not been attempted. It is shown that in general there is a fairly close relationship between the nature of the soils and the plant communities.

The soil mapping units are in general associations at the great soil group level. Some soil classification problems necessarily arose and while every effort was made to place the soils in Stephens' classification some modification was occasionally necessary. The soils are discussed in terms of the various great soil groups and their major morphological and chemical features are indicated. The more important soils occurring in the region are related to a greater or lesser degree to the grey and brown soils of heavy texture. However, the clay soils supporting a vegetation dominated by brigalow possess unusual features in that they display a very strong gilgai microrelief and frequently are extremely acid at shallow depths. In many closely associated areas weakly to moderately solonised soils bearing some relation to both the grey and brown soils of heavy texture and the red-brown earths are common. Solodized-solonetz, solodic, and solod soils are prominent in the east of the region where they occupy large areas. Other soils present include red-brown earths, lateritic red earths, alluvial soils, regosols, and lithosols.

The suitability of the soils for agriculture is discussed from the viewpoint of both chemical and physical factors and a table is presented summarising the chief features of each soil with reference to these and certain other properties. It is shown that certain soil groups may assume an agricultural importance but others are of very low potential productivity.

The genesis of the soils is discussed by considering the factors thought mainly responsible for their origin and occurrence. It is postulated that in particular the widespread influence of halomorphism has affected almost every soil group in the region. Other important factors discussed are the influence of parent material, topography, and drainage while past lateritisation and subsequent denudation probably played a major role in the genesis of certain soils now widespread in the region. Finally some observations are made on the nature and origin of gilgai microrelief.

I.—INTRODUCTION.

An extensive tract of land in Queensland is situated between the 20-inch and 25-inch rainfall isohyets extending northwards from the border approximately sub-parallel to the coast. This region possesses a wide range of soils some of which are becoming increasingly important agriculturally following clearing of the brigalow and belah forests which cover much of this land. The general nature of these soils has long been realised but little is known of their actual extent and variation. In an attempt to remedy this situation it was decided to commence a fairly broad study of the soils and related aspects of this region in order better to assess its potentialities With this end in view a fairly comprehensive study of the soils of the southern Queensland limit of the region has been made so that a firm foundation could be laid for future northward extension of the work.

Concomitantly with the soil investigations less detailed studies of the vegetation and geology of the region were made so that the general relationships between these three factors could be determined. The climatology of the region is also discussed ; this study has led to a better understanding of the effect of climatic factors on soil and plant associations as well as enabling certain predictions to be made regarding possible agricultural utilisation of some of the soils. The maps accompanying the report show the major soil associations, the distribution of cleared and uncleared brigalow and belah forests and cultivated land, and a smaller scale map illustrating the geology of the region.

1.—General Description of the Region Surveyed.

The region surveyed embraces an area of approximately 8,500 square miles, extending northwards from the Queensland-New South Wales State border as far as 27° 15′ S. latitude and lying within the limits of 149° 30′ to 151° 5′ E. longitude. This general locality has been variously referred to as the Border Downs, Western Downs, and West Darling Downs in several regional publications but no name is entirely appropriate for the limits of the area covered by the present survey. Accordingly it is referred to herein as the Inglewood–Talwood–Tara–Glenmorgan region.

The region generally is flat or very gently undulating with a large part of it covered originally by dense brigalow–belah forest, much of which has now been cleared. The region is drained by the Moonie, Weir, and Macintyre Rivers, the latter forming the border of the State. Annual rainfall ranges from 20 in. in the west to 25 in. in the east, of which two-thirds falls during the summer months of October to March inclusive.

Goondiwindi (population 2,950—figures are those of the June, 1954, census) is the largest town, while other centres include Inglewood (1,026), Tara (710), Talwood (170), and Glenmorgan (143). The southern part of the region is served by the south-western railway running through Inglewood, Goondiwindi, and Talwood while in the extreme north a branch line extends through Tara to Glenmorgan. The region is well served with roads, of which most are formed but virtually all are unsealed.

Most of the area is devoted to the sheep industry although both beef cattle breeding and fattening are also carried out. Agricultural activities are extending, mainly in the form of oats, wheat, and sorghum growing for fodder and grain purposes. Tobacco growing under irrigation has long been carried out fairly extensively along Macintyre Brook and the Dumaresq River.

2.—Survey Procedure.

A full cover of vertical aerial photographs mostly at a scale of 1 : 24,000 (approximately 1 inch = 30 chains) was available. These were used throughout supported by as many selected ground traverses as possible to enable a maximum number of representative soil profiles and natural features to be examined. This enabled soil boundaries to be reasonably accurately delineated on the aerial photos and thence transferred to the base maps of the Queensland Lands Department 2-Mile Series which were later reduced to give the final map at a scale of 1 inch = 4 miles. At least two and quite often more representative profiles were sampled and analysed for each soil group delineated.

II.—CLIMATE OF THE REGION.

1. General Climatic Characteristics.

The region lies within the 20 in.–25 in. rainfall zone with approximately two-thirds of the rainfall occurring during the summer months of October to March inclusive. A feature of the region is that appreciable winter rains may be reasonably expected in most years, this is in contrast with regions of similar longitude further north in Queensland. Summer temperatures are hot with the mean maximum temperature for the hottest months of December, January, and February in the vicinity of 92° F. The mean minimum temperature for July the coldest month is 41° F. Frosts are common and frequently severe during the winter months due to radiation cooling under typical Queensland anti-cyclone weather with clear skies and calm conditions.

(a) Rainfall Data.

Average monthly and annual rainfall figures for available stations are set out in Table 1, while Table 2 shows the seasonal distribution of rainfall. Figures for Dalby are included for comparison, this centre being situated some fifty miles east of Tara in an established grain growing area.

TABLE 1.

Monthly Distribution of Rainfall (Inches).

Station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Year.
Glenmorgan ..	3·11	3·35	2·51	1·05	1·20	1·17	1·02	1·11	1·08	2·23	2·45	2·59	22·87
Coomrith	2·84	2·45	2·60	1·21	1·29	1·51	1·47	·95	1·20	1·54	2·15	2·46	21·67
Talwood	2·59	2·86	1·86	1·07	1·44	1·47	1·40	·92	1·04	1·74	2·02	1·66	20·07
Goondiwindi ..	2·99	2·79	2·34	1·40	1·57	1·75	1·68	1·25	1·45	1·88	2·31	2·76	24·17
Inglewood ..	3·29	2·83	2·40	1·25	1·64	1·84	1·68	1·29	1·62	2·22	2·64	3·05	25·75
Tara	2·92	2·65	2·40	1·27	1·24	1·53	1·50	·77	1·05	2·09	2·57	2·90	22·91
Dalby	3·34	3·00	2·62	1·41	1·28	1·61	1·66	1·18	1·58	2·14	2·79	3·48	26·09

Number of years record :—Glenmorgan 22, Coomrith 63, Talwood 43, Goondiwindi 77, Inglewood 73, Tara 44, Dalby 86.

TABLE 2.

Seasonal Distribution of Rainfall (Inches).

Station.	Height Above Sea Level.	Number of Years Record.	Oct.–Mar. (inc.).	Per cent. of Total.	Apr.–Sep. (inc.).	Per cent. of Total.
	Feet.					
Glenmorgan	931	22	16·24	71	6·63	29
Coomrith	..	63	14·04	65	7·63	35
Talwood	611	43	12·73	63	7·34	37
Goondiwindi	720	77	15·07	62	9·10	38
Inglewood	932	73	16·43	68	9·32	32
Tara	1,022	44	15·55	68	7·36	32
Dalby	1,131	86	17·37	67	8·72	33

From the figures in Table 1 it may be seen that while January and February are normally the wettest months they are not markedly dominant over the remaining summer months. Early summer rains are usually characterised by heavy storms which may be erratic in extent and distribution but the rains of January, February, and March are usually much more widespread and usually result from rain depressions or a broad trough formation fed by a moist northerly air-stream. As shown in Table 2 appreciable rain falls during the winter months and although usually less intense than the summer rains occasional heavy falls may be experienced. These winter rains are usually produced by a trough formation forming a northern extension of a depression centred in the southern regions of the continent. As the trough moves through southern Queensland moist north-easterly air may be drawn in and be condensed by a following cold front and so produce scattered to useful falls throughout the region.

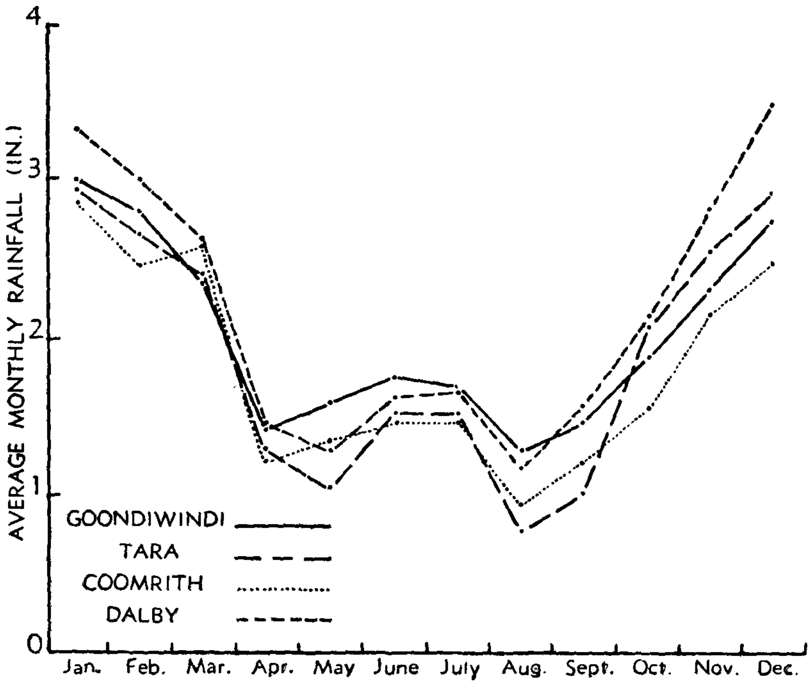

Figure 1.—Average monthly rainfall for selected stations.

The average monthly distribution of the rainfall is shown graphically in Figure 1. A feature of note is the sharp decrease for April registrations, followed by a rise for the months of May, June, and July, then a further decrease during August, the driest month of the year. The rainfall then steadily increases during the following summer months. For the stations available the annual rainfall shows a decline from east to west, this is more marked in the south of the region. There is also a tendency for the winter rainfall to decrease from south to north. It is interesting to note the fact that over a comparable number of years record both Goondiwindi and Inglewood receive more winter rain than Dalby.

TABLE 3.

NUMBER OF WET DAYS AND RAIN PER WET DAY (30-YEAR PERIOD 1911–1940).

Station.	—	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Coomrith ..	No. of Wet Days	4	4	4	2	2	3	2	2	2	3	4	4	36
	Rain/Wet Day	62	60	60	49	59	49	74	38	47	44	57	62	55
Goondiwindi ..	No. of Wet Days	6	5	4	4	4	5	5	4	4	5	6	7	59
	Rain/Wet Day	46	43	50	28	39	36	32	26	33	29	42	47	38
Inglewood ..	No. of Wet Days	7	5	5	4	4	5	5	4	4	5	6	7	61
	Rain/Wet Day	40	45	43	29	31	34	34	28	34	40	44	47	37
Dalby	No. of Wet Days	8	6	6	4	5	6	5	4	5	6	7	8	70
	Rain/Wet Day	45	41	41	35	22	30	29	24	26	30	43	45	34

In Table 3 above are shown the average number of wet days per month and the amount of rain per wet day for three stations with figures for Dalby included for comparison. The average intensity of rainfall as shown by these figures is only moderate but during the summer months heavy storms of short duration are common; the high intensity of these rains is frequently masked in tables showing average intensities due to the number of intervening occasions when only small rain totals are registered. It is also worth noting that proceeding from east to west there is a reduction in the number of wet days and a corresponding increase in the amount of rain per wet day.

Effective Rainfall—

It is doubtful whether climatic indices such as the Precipitation/Evaporation ratio as applied in southern Australia have a useful application in Queensland as the rainfall regime is greatly different. In north-eastern Australia the higher rainfall months coincide with months of high evaporation. As there are few evaporation figures in the region concerned any study of the effectiveness of rainfall has usually to be based on saturation deficit measurements. However these are calculated from 9 a.m. wet and dry bulb readings which may not necessarily give an accurate picture of the mean daily saturation deficit. Using the precipitation/saturation deficit ratio of Prescott and Thomas (1949) the monthly values for Goondiwindi and Dalby are plotted in Figure 2.

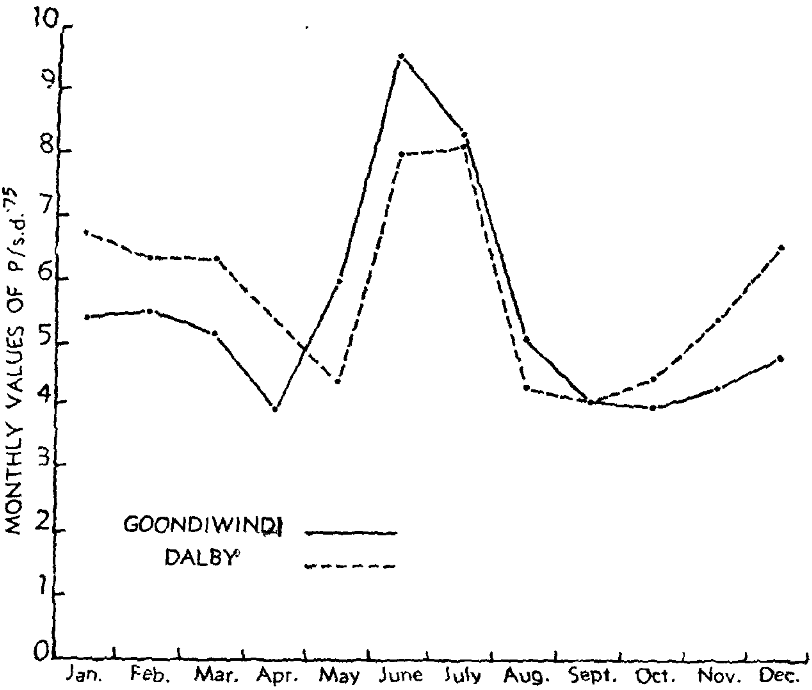

Figure 2.—Monthly P/s.d values for Goondiwindi and Dalby.

Prescott and Thomas state that a value of 4 of this ratio corresponds approximately to the original value of P/E of one-third as used in southern Australia, that is a value of 4 is considered to constitute the "break of season." However this must be supported by a number of months in which the value of the index is 8 or over, this value being necessary to maintain growth under conditions of low transpiration or for start of drainage through bare soil. On this latter basis therefore it might be considered that the leaching power of the climate is relatively low in this region. This fact is further supported by a study of the soils themselves. It is considered unlikely that this climatic index is of much value in predicting the possible length of a growing season in Queensland as environmental conditions are entirely different to those of southern Australia. Thus the above index would suggest that at both Goondiwindi and Dalby there is not an adequate growing period for summer crops, this is contrary to actual experience in these areas. Also the index does not allow for the utilisation of moisture stored by means of a fallow.

(*b*) Temperature and Humidity Data.

Temperature and relative humidity data for Goondiwindi (the only station with available data), together with comparative figures for Dalby, are shown in Table 4.

TABLE 4.

Average Temperature (°F) and Relative Humidity (9 a.m.) Data.

(Based on 30 years record).

Station.	—	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Goondiwindi ..	Max. Temp.	93·5	92·1	87·8	80·7	72·4	65·6	64·4	68·9	75·9	83·0	88·7	91·8	80·4
	Min Temp.	67 3	66·4	62 6	54·6	47·4	43·0	41·3	42·8	48·8	55·8	61 9	65·4	54·8
	Mean Temp.	80·4	79·2	75·2	67·6	59·9	54·3	52·8	55 8	62·3	69·4	75·3	78·6	67·6
	Rel. Hum.%	54	57	59	62	66	73	71	64	55	51	50	50	59
Dalby	Max. Temp.	89·8	88·4	85·3	79·8	72·8	66·9	65·9	69·6	76·8	83 5	86·9	88·9	79·4
	Min. Temp.	64·7	63·9	60·6	53·5	46·4	41·8	40 0	41·3	47·4	54·7	60 2	63·5	53·2
	Mean Temp.	77·3	76·1	72 9	66·6	59·6	54·3	52 9	55·4	62 1	68·6	73·5	76·2	66·3
	Rel. Hum.%	58	60	62	63	66	72	70	62	53	51	52	55	60

The average monthly temperature for Goondiwindi and Dalby are shown graphically in Figure 3.

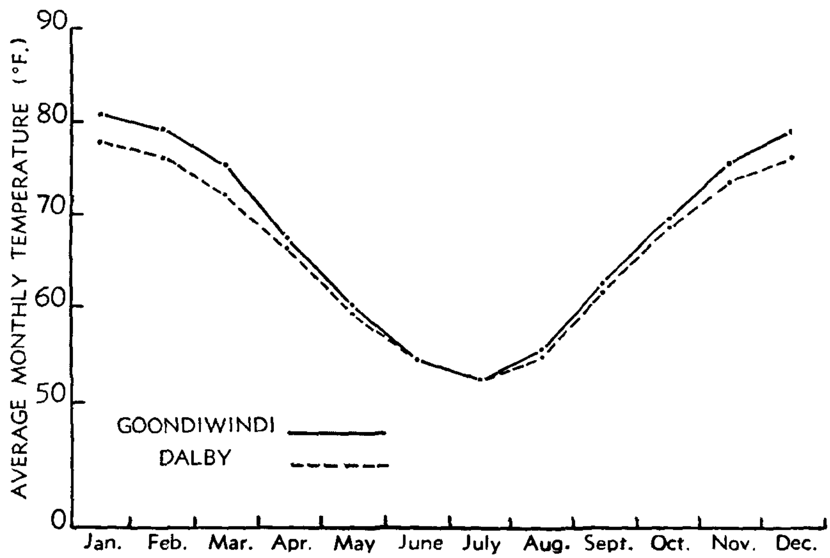

Figure 3.—Average monthly mean temperature for Goondiwindi and Dalby.

From this figure it may be seen that Goondiwindi has almost as severe a winter as Dalby but summer maximum temperatures are higher. The coldest month is July with a mean minimum temperature of 41·3° F. and January is the hottest month with a mean maximum of 93·5° F. During the summer months temperatures of over 100° F. may be frequently recorded.

Frosts are common and frequently severe in the region during the winter months. Data from Foley (1945) are presented in Tables 5 and 6 and show the occurrence of first and last frosts, average frost free period and frost frequency. A screen temperature of 33° F—36° F. is considered to represent a light frost and 32° F. or under a severe frost. Figures for Dalby are shown for comparison.

TABLE 5.

OCCURRENCE OF FIRST AND LAST FROSTS AND AVERAGE FROST FREE PERIOD.

First and Last Frosts—Headings.

1. Average Date of first/last occurrence (ten year period 1930-39).
2. Mean deviation from average date (days).
3. First/last recorded date of occurrence since 1908.

Station.	Height.	First 36°.			First 32°.			Last 32°.			Last 36°.			Average Frost Free Period (36°).
		1	2	3	1	2	3	1	2	3	1	2	3	
	Ft.													
Goondiwindi	720	May 31	12	Apr. 17	June 30	20	May 19	Aug. 3	21	Sep. 13	Aug. 29	10	Oct. 16	274 days
Dalby ..	1,131	May 18	15	Apr. 17	June 17	11	May 8	Aug. 23	12	Sep. 16	Sep. 13	9	Oct. 1	246 days

TABLE 6.

FROST FREQUENCY.

AVERAGE NUMBER OF DAYS PER MONTH OF MINIMUM SCREEN TEMPERATURES OF 32°F. OR UNDER.

(BASED ON 10 YEARS' RECORD).

Station.	June.	July.	Aug.	Sep.	Year.
Goondiwindi ..	1·9	1·4	1·2	1	4·6
Dalby	4·2	4·3	3·7	0·5	12·7

For Goondiwindi the average number of days per year with a screen temperature between 32° F. and 36° F. is 16. From Table 6 it is seen that severe frosts are not as common at Goondiwindi as compared with Dalby.

2.—Climate in relation to Agriculture.

Rainfall is the most important climatic factor influencing plant growth in the region but its incidence and reliability are far more important than the total amount. Table 1 shows that the average rainfall is reasonably well distributed at most stations except for short drier periods during autumn and spring. With regard to winter crops such as wheat and oats, the rainfall may be grouped to cover the fallowing period (December to April), the planting period (May and June) and the growing period (July to October).

The result of such a grouping is shown in Table 7.

TABLE 7.

RAINFALL DISTRIBUTION IN RELATION TO WHEAT GROWING.

Station.	Fallowing (Dec.–Apr.).	Planting (May–June).	Growing (Jul.–Oct.)
	In.	In.	In.
Glenmorgan	12·61	2·37	5·44
Coomrith	11·56	2·80	5·16
Talwood	10·04	2·91	5·10
Goondiwindi	12·28	3·32	6·26
Inglewood	12·82	3·48	6·81
Tara	12·16	2·77	5·41
Dalby	13·85	2·89	6·56

From these figures it is seen that the fallowing rains are somewhat less than those of Dalby, the planting rains are comparable (or better in the case of Inglewood and Goondiwindi), while the growing period rains are in most instances only slightly below those for Dalby.

Successful growth of winter crops in Queensland is to a large extent dependent on an adequate rainfall during the summer fallowing period. For this reason the reliability of the December-April rains in the region under discussion has been assessed by showing in Table 8 the percentage frequency of receiving a stated amount of rain or more for this summer fallowing period.

TABLE 8.

RELIABILITY OF DECEMBER–APRIL FALLOWING RAINS.

Station.	Percentage frequency of receiving stated amounts or more.			
	14 in.	12 in.	10 in.	8 in.
Coomrith	26	37	61	79
Talwood	19	27	54	70
Goondiwindi	33	44	64	86
Inglewood	44	59	71	87
Tara	31	44	64	82
Dalby	44	64	82	89

Number of years record—Coomrith 62, Talwood 38, Goondiwindi 72, Inglewood 68, Tara 39, Dalby 80.

From this table it may be seen that in the western parts of the region—as indicated by Coomrith and Talwood, the chances of receiving an adequate fallowing rain are somewhat low. Goondiwindi and Inglewood compare favourably with Dalby for receiving 8 inches or more ; the chances of receiving higher totals at Goondiwindi are somewhat less than at Dalby but at Inglewood the chances are nearly comparable. The chances of receiving 10, 12, and 14 inches or more at Tara are equivalent to those of Goondiwindi but are somewhat less for 8 inches or more.

While the total amount of rain received during this fallowing period is important a more *critical criterion is the proportion of this rain that is actually absorbed and retained in the soil.* Thus light falls of rain may fail to penetrate deep enough into clay soils to escape subsequent loss by evaporation. Also experience has shown that with heavy rainfall on clay soils although the initial rate of penetration may be high it rapidly falls off as the surface soil becomes saturated and subsequent rainfall does not enter the soil but is lost by run-off and evaporation. There is a real need for data concerning the actual amounts of water that can be stored in the soil, for this is the only satisfactory basis on which possible crop yields can be predicted. There are thus two aspects to be considered, firstly the proportion of the rainfall that might be expected to be absorbed and retained by the soil and secondly the capacity of the soil in question to store adequate quantities of water.

The result of a more detailed analysis showing individual monthly rainfall probabilities for each station is presented in Table 9. This shows the percentage frequency of receiving certain specified amounts or more per month.

An idea may be gained from this table of the reliability of planting rains in May and June for winter crops. An adequate planting rain is better regarded as one which will wet the soil to sufficient depth so as to link up with moisture already conserved in the soil from the summer fallow rather than to define it arbitrarily as a fixed amount of rainfall. However as a basis for comparison it is assumed that 1½ inches in May or June will be sufficient for planting requirements although it is to be realised that this may not occur in one rain period. Using this figure it can be seen from the table that the chances of receiving 1½ inches or more in May are fairly low for all stations (30–40 per cent.) but both Goondiwindi and Inglewood are more favourably situated than Dalby. In June the chances for all stations are higher (40–50 per cent.) and in this month all stations, except Coomrith, have better chances than Dalby. The position with regard to rainfall during the growing season is rather similar in that both Goondiwindi and Inglewood have slightly better chances of receiving a stated amount of rain or more than Dalby. Tara does not appear to be as favourably situated.

From this brief analysis it would appear that considering rainfall alone the chances of successfully growing winter crops in the Goondiwindi-Inglewood region should compare favourably with Dalby although in general the summer fallowing rains are somewhat less. Hounam (1950) in a similar but more detailed study of the north-west wheat belt of New South Wales suggested that a line approximating the western limit of economic wheat production in that region runs south-westerly from a point midway between Boggabilla and Bengalla.

With regard to rainfall for summer crops the percentage frequencies of occurrence at Inglewood generally approach or slightly exceed those for Dalby with Goondiwindi and Tara usually somewhat less. The chances of receiving planting rains of 2 inches in October are less than 50 per cent. but this improves for Inglewood and Tara in November to the vicinity of 60 per cent. while in December chances for all stations, except Coomrith and Talwood, are over 60 per cent. In January the chances of receiving 2 inches or more are 65 per cent. or slightly better at Inglewood and Tara, but for February only Goondiwindi and Inglewood have a 50 per cent. or better chance of receiving 2 inches or more. For March only Coomrith has a better than 50 per cent. chance of recording 2 inches or more. In general this analysis would appear to indicate that most of the region is not as favourably situated with regard to summer crop growing as is Dalby.

TABLE 9.

MONTHLY RAINFALL PROBABILITY.

PERCENTAGE FREQUENCY OF RECEIVING THE STATED AMOUNTS OR MORE PER MONTH.

—		Coomrith.	Talwood.	Goondiwindi.	Inglewood.	Tara.	Dalby.
	In.						
January	½	90	82	96	97	95	94
	1	83	77	86	91	90	83
	1½	68	59	68	77	75	78
	2	51	56	58	65	67	68
	3	33	28	42	43	40	50
February	½	76	72	90	88	87	88
	1	68	56	77	75	77	76
	1½	59	49	60	65	52	65
	2	44	46	51	59	37	54
	3	29	33	37	35	30	40

TABLE 9—*continued.*

MONTHLY RAINFALL PROBABILITY.

PERCENTAGE FREQUENCY OF RECEIVING THE STATED AMOUNTS OR MORE PER MONTH.

—	In.	Coomrith.	Talwood.	Goondiwindi.	Inglewood.	Tara.	Dalby.
March	½	78	57	79	80	75	89
	1	76	51	68	65	62	74
	1½	68	49	53	56	60	63
	2	60	41	42	42	40	51
	3	33	26	32	32	30	40
April	½	65	59	64	59	67	67
	1	52	41	49	48	45	55
	1½	32	28	41	33	35	38
	2	22	18	27	25	22	27
	3	8	3	10	9	10	13
May	½	57	69	70	72	57	68
	1	44	44	55	56	45	43
	1½	30	33	37	38	32	34
	2	24	23	22	27	20	26
	3	11	18	11	16	10	7
June	½	70	90	78	78	77	77
	1	56	56	60	65	65	57
	1½	41	46	47	51	47	43
	2	29	28	37	35	25	32
	3	10	13	18	17	15	15
July	½	75	67	79	77	77	78
	1	57	46	56	64	52	65
	1½	38	31	45	45	42	44
	2	24	26	33	32	20	29
	3	10	10	15	13	7	15
August	½	51	49	70	71	55	60
	1	33	41	49	48	35	40
	1½	22	26	36	30	20	29
	2	14	15	19	23	12	17
	3	3	5	7	19	2	7
September	½	70	64	75	80	67	85
	1	46	49	62	65	35	61
	1½	32	26	41	42	27	45
	2	16	26	27	35	15	30
	3	5	8	12	13	2	13
October	½	68	85	85	88	82	89
	1	49	62	66	68	72	73
	1½	38	38	51	58	52	55
	2	33	28	36	43	40	44
	3	19	15	15	23	20	22
November	½	76	79	89	88	82	77
	1	67	72	73	80	77	67
	1½	56	54	60	68	67	61
	2	48	46	45	62	57	52
	3	29	21	26	22	32	39
December	½	90	79	88	94	90	95
	1	76	74	82	85	85	89
	1½	62	56	73	81	75	82
	2	54	44	60	65	67	68
	3	38	33	38	43	32	46

Number of years record.—Coomrith 63, Talwood 39, Goondiwindi 73, Inglewood 69, Tara 40, Dalby 82.

III.—PHYSIOGRAPHY OF THE REGION.

The region forms part of the south-eastern corner of the Queensland portion of the Great Artesian Basin and is not a naturally distinct physiographic or geological province. In particular the northern and western boundaries are purely arbitrary and do not bear any relation to physiographic or geological features.

1.—The Surface Features.

The greater part of the region, lying west of the limits of the lateritised sandstones of the Blythesdale Group, is essentially a plainland. Although undulating in parts and in some areas with the flat surface interrupted by low lateritic scarps and mesa-like residuals it is in general a broad flat to gently rolling terrain some 600 to 1,000 feet above sea level with a general westerly slope except in the north-west where there is a local deviation from this general pattern.

Although in the east the sandstones of the Blythesdale Group form a naturally distinctive terrain—rather more broken and undulating, their western limit is usually not marked by a prominent scarp except in the entrenched region about the head of Wyaga and Yarrill Creeks. Elsewhere the clay-soil-covered plainlands merge gradually into the often sand-strewn or stony lateritic ridges of the Blythesdale Group. South of Inglewood in the extreme south-east, parts of the old massif of Palaeozoic rocks forming the marginal basement of the Artesian Basin protrude through the later sedimentary cover to give small maturely dissected hilly areas that form a sharp contrast to the level nature of the region as a whole.

Scattered throughout the central and northern parts of the region are low lateritic residuals that may take the form of buttes, mesas, small plateaux or occasionally cuestas. These rarely exceed 50 feet in height but are often bounded by fairly steep scarped margins. An exception to this elevated nature is found along several creeks south of Glenmorgan where lateritic material is exposed mainly in the stream beds.

2.—The Drainage Pattern.

Although the regional gradient is dominantly from east to west there is also a southerly component that is reflected in the upper courses of most of the streams. This is evidenced by the drainage pattern of all but the north-western part of the region. Most streams in the early part of their courses at least, tend to flow in a south-westerly direction for some distance towards their ultimate objective, the Macintyre River. However, before this is reached there is a general tendency for the streams to swing westerly and flow more or less parallel to that stream before ultimately joining it. This pattern is strikingly displayed by the Weir River which runs almost due south towards the Macintyre until north of Gooray where it abruptly swings west and parallels the latter stream until south-west of Talwood.

The reason for this phenomenon is not particularly clear as the divides between streams are in most cases insignificant rises that are not arranged in any apparent pattern. Most likely the stream pattern is to be related to the low gradients which obtain over the lower reaches of many of these watercourses. This combination of low gradients and broad flat lands has produced somewhat similar but usually more pronounced peculiarities of drainage patterns in many of the western Queensland rivers.

The divide between the Moonie and Weir Rivers is quite clearly defined in the region west of Parkhurst. Here a fairly high east-west ridge runs close to the course of the Moonie River and this has been responsible for there being very few tributaries joining the river from the south as contrasted to the numerous streams which flow in almost at right angles from the north.

A deviation from the general westerly drainage pattern occurs in the north-west of the region where all streams flow northerly to join the Condamine. This is largely a result of the presence of the higher lateritic residual areas to the north of Coomrith, which were very likely elevated by an uplift in the late Tertiary or Pleistocene.

Throughout many of the extensive densely forested flat clay soil areas there is virtually no surface drainage. These are usually regions of profuse gilgai microrelief and the deep depressions serve to collect rainfall run-off which often does not find its way to any recognisable streamline.

3.—The Stream Types.

Some of the more important streams where they traverse areas of gentle gradient develop the typical western Queensland habit of being multi-channelled. This is particularly evident on the lower reaches of the Weir River and the Macintyre River west of Goondiwindi where the gradient is approximately 12 inches per mile. Often there are only two channels, the main channel and a minor one—such as the Callandoon Branch of the Macintyre, but occassionally there are more than two and anabranches and billabongs commonly develop. Both the main stream and the associated channels typically exhibit a strong meandrine pattern but many of these subsidiary channels are non-functional in all but the higher floods.

As might be expected from this pattern the area between the channels is frequently inundated even during only moderate floods. This flooding may often extend far from the main channel of the stream and reaches its maximum in the area between the Macintyre and Weir Rivers where they are sub-parallel. This region may become virtually completely inundated in high floods except for localised higher spots and the old " dead " sandridges which are usually at a higher elevation than the surrounding flood plain.

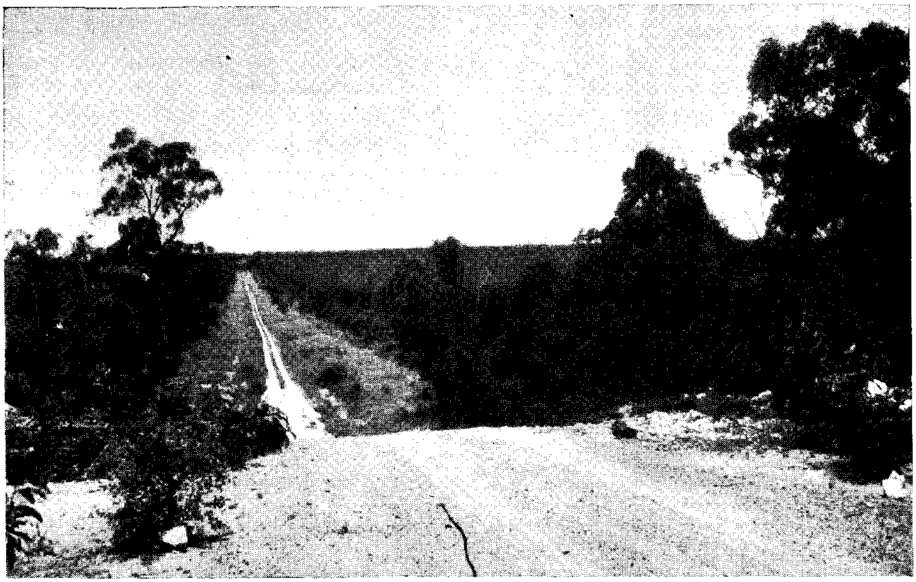

Plate 1.

Scarped margin of the lateritised Blythesdale sediments 6 miles north of Yagaburne. Here there is an abrupt change to the lower gilgaied clay brigalow country but elsewhere the Blythesdale group is normally only slightly higher than the surrounding clay soil plainlands.

Plate 2.

An aerial photo (approx. scale 30 chains = 1 inch) showing the flat grey clay areas near Bungunya traversed by Yarrilwanna Creek, an anabranch of the Weir River. Nearly all streams in this region display this meandrine pattern due to the very low gradients that obtain (less than 12 inches per mile).

Plate 3.

The Moonie River at the Meandarra road crossing north of Westmar with the banks characteristically lined with coolibah.

Plate 4.

The Dumaresq River south of Kurumbul showing the typical fringing forest of flooded gum and coolibah. The river here forms the border between Queensland and New South Wales.

IV.—GEOLOGY OF THE REGION.

The region forms part of the south-eastern extremity of the Queensland portion of the Great Artesian Basin and for this reason has to be regarded as part of a much larger structure and not as a separate geological entity in its own right. The Palaeozoic basement rocks of the Artesian Basin are the oldest rocks present in the region. Unconformably resting on these are many of the gently westerly dipping Mesozoic formations that constitute the bulk of the sediments of the Great Artesian Basin. Younger formations outcrop progressively to the west but in many cases these are obscured by Tertiary lateritic developments and Quaternary deposits. More detailed accounts of the Mesozoic sequences are given by Whitehouse (1952, 1954).

The accompanying geological map has been extended slightly in the south-east outside the defined limits of the region discussed elsewhere in this report. This was considered necessary to permit a better understanding of the geological features of this area which have an important bearing on the region as a whole.

1.—The Palaeozoic Basement.

Only very limited areas of the old basement rocks outcrop in the south-east of the defined region but these are continuous with the extensive massif of Palaeozoics that occurs further to the east in the direction of Warwick and Stanthorpe. The rock types are black and grey cherts and silicified mudstones, usually steeply dipping and with a prominent cleavage parallel to the bedding. In the south of the region the strike is submeridional but further north swings more to an east-west direction.

The precise age of these Palaeozoics is not known. Between Limevale and Texas similar rocks contain a fairly large limestone lens (often silicified but apparently unfossiliferous) that appears very similar to the fossiliferous limestones of Gore and elsewhere that have been ascribed to the Silverwood Group of Lower or Middle Devonian age. South of the New South Wales border around Texas similar rocks are held to be of Devonian age so that on this admittedly scanty evidence it might be suggested that these old basement rocks are of Middle rather than Upper Palaeozoic age although further east around Silverspur and Gunyan Upper Palaeozoic rocks are developed. It may also be mentioned here that two miles south-east of Smithfield there is a small outcrop of granodiorite that is doubtless the northern extremity of the much more extensive granitic areas south of the Dumaresq River in New South Wales.

2.—The Mesozoic Sequences.

Although the more important Mesozoic developments are represented in the region outcrops are few and the picture is further complicated by the fact that nearly every post-Palaeozoic formation has been affected by lateritic influence to a greater or lesser degree.

(*a*) The Bundamba Group.

The earliest Mesozoic sediments recognised in the region are those of the Bundamba Group. Previous investigators (e.g. Whitehouse 1954) had not recognised the Bundamba Group as occurring further south than the south-western railway in the vicinity of Cobba-da-mana, some ten miles east of Inglewood. Further south the sediments resting on the Palaeozoics were held to be those of the Blythesdale Group. It is now thought however that the Bundamba sandstones are represented in this south-eastern corner, resting unconformably on the Palaeozoic basement. The evidence for this is admittedly not strong as not only is there a paucity of outcrops but where exposed the sediments are invariably partially or completely lateritised. Nevertheless the sandstones in the vicinity of Cobba-da-mana may be traced in a south-westerly direction almost to the border, with their irregular eastern margin resting unconformably on the old basement rocks.

From the few available outcrops and one bore log it would appear that shales and mudstones form a rather more important constituent of the Bundamba Group in this region than elsewhere, but in a few localities such as in the vicinity of Magee there are exposed coarse siliceous sandstones more typical of the Bundamba as known elsewhere. Usually though all outcrops show some sign of lateritic influence, with outcrops of mottled zone material fairly common. An additional fact in favour of a Bundamba rather than a Blythesdale age for these sediments is that the soils and terrain developed on them are rather different in many aspects from surface features of the known Blythesdale Group further west. This difference in surface features also results in most areas in a slightly different aerial photo pattern. Due to the poor development and paucity of exposures it is not possible to ascertain which of the normal three-fold divisions of the Bundamba Group as developed elsewhere are represented in this sequence.

(*b*) The Walloon Coal Measures.

In this region the Walloon Coal Measures rest directly on the Bundamba Group or the Palaeozoic basement and the Marburg Formation does not appear to be developed. As Whitehouse (1952, 1954) has shown the south-eastern area of Queensland centered about Toowoomba seems to have been a mobile axis of uplift in Marburg times and as the region to the south and east of Inglewood is near the Palaeozoic basement it is quite conceivable that here too, uplift occurred during the Marburg interval resulting in the non-development of that formation. However, the Marburg is frequently a difficult formation to recognise as usually it tends to be transitional between the siliceous sandstones of the Bundamba Group and the calcareous sandstones and shales of the Walloon Coal Measures.

The Walloon Coal Measures are best developed to the east of Inglewood extending as far as the Bundamba margin at Cobba-da-mana. As is customary with much of the Walloon terrain in South-east Queensland outcrops are few but the typical lowland to gently undulating topography with dark clay soils, presumably a consequence of the apparent shaly and calcareous sandstone nature of the sediments, is characteristically developed east of Inglewood. Further south occupying a narrow strip along the Dumaresq River from near Texas downstream as far as Brush Creek is another occurrence of undulating clay soils that is apparently a Walloon development. In this area the few outcrops—such as those near Borella, show brown and pale yellowish to almost white sandy mudstones that have been weakly lateritised in parts. It would appear that in none of these areas are there any carbonaceous beds developed.

While the Walloon Coal Measures in the vicinity of Cobba-da-mana rest on the Bundamba Group it is evident that there is only a shallow cover over the basement as north-west of Cobba-da-mana there is an inlier of Palaeozoic rocks while just north of the township of Inglewood there is a similar inlier. The Walloon development along the Dumaresq River rests directly on the Palaeozoics north-west of Texas but in the region between Magee and Borella it rests upon the Bundamba Group. Again in this region around Smithfield there is a small inlier of Palaeozoic rocks within the Walloons.

The characteristic landscape of this formation is covered by grey clay soils which closely resemble the extensive clay sheets developed further west in the region and it is very likely that some of these areas are not derived in situ from the Walloon Coal Measures but are a later Quaternary development. This is especially so in the vicinity of Coolmunda, to the east of Inglewood.

An anomalous feature remains to be accounted for. Existing geological maps (e.g. Whitehouse 1954) show a tongue of Walloons extending south-westerly through Inglewood to the vicinity of Bethcar. This was presumably mapped as such on the basis of the clay soil cover found in this area. However, deep soil boring has failed to reveal the presence of Walloon sediments and it is considered much more consistent to map this region as a Quaternary deposit. Thus south-south-west of Inglewood to the vicinity of Brush Creek there are apparently no Walloon Coal Measures developed, or at least the typical outcrops are not represented. Two possible explanations come to mind. Either the succeeding Blythesdale Group overlapped on to the Bundamba Group in this region or sandy material shed from these two sandstone formations has completely obscured the Walloon outcrops. A similar problem is encountered along Canning Creek north-east of Inglewood where again there is a gap in the expected Walloon development. Here also a similar explanation probably applies to account for an apparent Blythesdale–Bundamba junction.

(c) The Blythesdale Group.

Although the mapped outcrop area of the Blythesdale Group in the region is extensive this is a most difficult formation to describe in terms of original lithology as almost every outcrop displays a greater or lesser degree of lateritisation. It would seem that sandstones dominate the sequence but shales and sandy mudstones also appear fairly common, usually in thin bedded units. The Blythesdale terrain is characterised by stony lateritised sandstone ridges, deep sandy cypress forest areas and light coloured solonised soils carrying bull oak, a combination of surface features which makes it readily identifiable in most outcrop areas.

In nearly all areas the original Blythesdale sediments have been profoundly modified by later lateritic processes. It is doubtful whether much, if any, of the original ferruginous zone of the laterite profile is now preserved but everywhere outcrops of mottled zone material are abundant. In only a few cases are there exposures which have reached to the base level of the zone of lateritic influence.

The western margin of the Blythesdale Group is well defined in the north and south of the region where it is marked by an abrupt change from sandy soils with stone outcrops to the later extensive flat clay soil plainlands. However, in the central part of the region particularly in the general area around the junction of Booroondoo Creek and the Weir River it is difficult to establish the upper limit of the lateritised Blythesdale Group as scattered throughout this region and extending intermittently to the west are numerous lateritic residuals that could represent lateritised Blythesdale sediments or lateritised later deposits. Some of these occurrences especially those about the head of Wyaga and Yarrill Creeks very likely are merely residuals of the once more extensive Blythesdale outcrop zone, but it is quite possible also that even some of the lateritic outcrops to the east of the Blythesdale upper limit represent later lateritised deposits resting upon the Blythesdale Group. It has not been possible to recognise subdivisions of the Group as has been done in the Roma district.

(d) The Rolling Downs Group.

Several small areas of the marine Lower Cretaceous Roma Formation are present in the area. These had previously been recognised and mapped by Whitehouse (1954). Although in the region described in this report no fossils have been found the beds around Coomrith extend westerly towards Surat and in this continuation Roma Formation faunas have been found. Where they outcrop the marine sediments have a characteristic rolling downs surface that is rather more strongly undulating than the typical western Queensland occurrences. (Plate 16). Surface outcrops are few and invariably consist of yellowish to buff coloured calcareous sandstones, less commonly shales. However, below the zone of weathering as evidenced by bore logs bluish and greyish colours predominate.

Although the most easterly outcrop of the Roma Formation in the vicinity of the Weir River approaches the western limit of the Blythesdale Group, in the north there is a wide gap that is covered with later superficial materials and lateritic outcrops. However, bore logs appear to indicate that at relatively shallow depths the Roma Formation does extend at least as far east as the vicinity of Tara. In the south the picture is not so clear. Whitehouse (1954) has remarked that the approximate line of the Weir River (a north-east line) marks some unexplained change of geology. South-east of this line is a region of abundant shallow artesian waters, to the north-west there are few shallow waters and pressures also differ on either side of this line. The reason for this phenomenon is still unknown. Limited available bore logs suggest that while the region to the north-west of this line is underlain by the Roma Formation (an aquiclude) at shallow depths this is not so south-east of the line where shallow bores penetrate pervious sandstones with some shales. Another feature is that south-east of the line there are very few lateritic outcrops as contrasted to the abundant occurrences to the north-west.

It is uncertain whether the Roma Formation has been affected by lateritic influence. Certainly where undoubted outcrops of calcareous sandstone occur there appears to have been no such effect but in the vicinity of and overlying some of these marine areas are mottled zone scarps and residuals that could possibly represent the lateritised upper portion of the Roma Formation that has not yet been stripped by erosion to expose the original calcareous sediments. This question will again be referred to in the next section.

3.—Cainozoic Developments.

Owing to the widespread lateritic influence that has affected nearly every sedimentary outcrop in the region it is frequently difficult, if not impossible, to decide on original lithologies. Also the degree of dissection which has operated since the period of lateritisation has further complicated the task of interpreting the more recent stratigraphy of the region. As may be seen from the map west of the limit of the Blythesdale Group there are numerous lateritic residuals the age and original nature of which are very much in doubt. All available bore logs have been examined and in some instances these have proved helpful so that for some areas a degree of probability may be assumed.

(*a*) The Moonie Formation.

In the central western part of the region just south of the Moonie River a high undulating sandy ridge forms the divide between the Moonie and Weir Rivers. The Moonie Highway takes advantage of this ridge and outcropping at various widely spaced intervals from near Parkhurst in the east to south-west of Flinton are a series of sediments that have been lateritised to varying degrees. It is proposed to name this development the Moonie Formation.

Although outcrops are poor it would appear that the sequence consists of white to pale brown sandstones and grits which are often only weakly cemented. Some whitish clays and mudstones may also occur but it was not possible to ascertain the thickness of the formation. In some areas the sediments have been quite strongly lateritised. The crests of some ridges have a red soil with outcrops of material displaying a strong reticulate red and white mottling. In other areas this mottled zone material is merely represented by dark-red ferruginous sandstone with lighter colour variations.

Possibly this formation is to be related to the Glendower Formation (Whitehouse 1940) but the often strong evidence of lateritisation is not in accordance with the suggestion of Whitehouse that the Glendower Formation is later than the main period of lateritisation. It is more likely then that this Moonie Formation is of early or middle Tertiary age.

(*b*) The Problem of the Laterite.

The numerous lateritic residuals that are so common in the northern and central part of the region all consist of mottled zone material and in many cases the lateritic processes have been so pronounced as to profoundly alter the original nature of the sediment. In many instances the mottled zone consists of massive kaolinitic material with reticulate red mottling with occasionally a nodular structure developed. In other instances where either the lateritic influence has not been as strong or exposures are nearer the base of the profile there is only a broad weakly developed mottling present and it is possible to obtain some idea of the nature of the original sediments. These may be banded shales and mudstones—often with shale pellets, or more typical fine to medium grained sandstones. The more extensive plateaux between Coomrith and Glenmorgan appear to consist originally of brownish sandstones that are now often ferruginous in part and usually display a weak mottling. In no instance has any evidence of extensive silicification or exposures of billy been found in any of these mottled zone occurrences. Likewise nowhere has there been definitely recognised in surface exposures the upper ferruginous zone of the laterite profile although at the Meandarra road crossing of the Moonie River there is a suggestion that the small outcrop may be very near the top of the mottled zone. However, this outcrop is topographically lower than the neighbouring mottled zone residuals. The pallid zone is probably represented in some outcrops although usually there is still some trace of faint red mottling.

It is quite impossible on present evidence to assign a definite age to these lateritised sediments. It has been pointed out earlier that it is thought that the Moonie Formation is quite distinct from the lateritic occurrences referred to above but with regard to these much more extensive lateritic residuals to the north of the Moonie Formation there is no definite indication of age. Whitehouse (1954) has stated that similar lateritised sediments of the Maranoa district which cap the Cretaceous beds are best correlated with the early Cainozoic Eyrian Formation. There is really no evidence to refute or confirm this hypothesis beyond suggesting that north of Coomrith and west of Glenmorgan the lateritic plateaux apparently capping the Roma Formation could represent an upper lateritised section of this formation which, around Coomrith and elsewhere, has been stripped by erosion to expose the unaltered marine sediments. Against this is the fact that in only one locality in far western Queensland (Whitehouse 1940) has there been found undoubted evidence of lateritised marine Cretaceous sediments. It is also worth remembering that in this south-eastern corner of the Great Artesian Basin the Cretaceous formations succeeding the Roma elsewhere in the basin—the marine Tambo Formation and the lacustrine Winton Formation—have not been recognised so that post-Roma lateritised sediments are not necessarily of Tertiary age.

It must also be stated that this region does not provide any evidence of when the lateritisation took place but it seems probable that there was more than one period of lateritisation.

(c) Post Laterite and Recent Deposits.

Three miles east-north-east of Yelarbon there is a low ridge composed of conglomerate and coarse grits. Although poorly exposed usually the upper section is heavily impregnated with limonitic material while at shallow depths this is replaced by an almost white conglomerate which is only weakly cemented. The conglomerates are composed mainly of quartz and other siliceous rocks (cherts and jaspers) but no billy was seen. This occurrence appears to underlie the Yelarbon " desert " as shallow wells in the township penetrate water-bearing gravels while to the north of Yelarbon near the desert margin an earth tank has exposed white fairly coarse weakly cemented sandstones and grits which may occasionally display a very weak orange mottling. Deep soil boring investigations have also revealed the presence of uncemented sands at shallow depths south-east of Yelarbon.

Although no billy has yet been found in it this deposit would appear to be more typical of the Glendower Formation as it is known from other parts of Queensland. The very weak indication of lateritisation would also be in keeping with the contention of Whitehouse (1940) that the Glendower sediments were deposited subsequent to the main period of lateritisation.

Covering extensive areas throughout the region are sheets of clay soils that support a dense vegetation of brigalow, belah, and other species. Many of these clays have a strongly developed gilgai microrelief with the depressions ranging up to four or even six feet in depth. It is also throughout these areas that low residual outcrops of mottled zone material frequently occur, and as shown by excavated earth tanks, bore logs and deep soil borings, this mottled zone of the laterite profile underlies most of this spread of clay soils at depths which usually do not exceed 25 feet and may frequently be much less. This relationship is discussed at greater length when dealing with the genesis of the soils but a few points may be noted here.

Firstly, there is usually a fairly distinct break between these clays and the underlying truncated laterite profile so that in most cases it is unlikely that they have formed in situ from this lower material even though the lower levels of the clays may display a fairly distinct red and grey mottling, and are normally strongly acid. This is supported by limited clay mineral studies (C.S.I.R.O., unpublished information) which have shown that the clay materials, even when strongly acid, are dominantly montmorillonitic, as contrasted to the kaolinitic mottled zone material of the truncated laterite profile. Secondly, the extremely uniform nature of these clays, not only in this region but also elsewhere in Queensland, is very different from the typical indisputably alluvial riverine deposits. This would suggest a particular widespread set of environmental conditions of deposition and probably also a particular uniform parent material. It would seem likely that in many instances these clay materials resulted from past denudation of the once widespread laterite profile but the manner in which this material was removed and deposited is still in doubt. It may be mentioned here that there appears to be a possibility that some of these clay materials may be of aeolian origin, as in many cases they strongly resemble the typical parna (Butler 1956) which is so widespread in southern Australia. The C.S.I.R.O., Division of Soils has also been concerned with the nature and origin of these clay materials and similar suggestions as to their origin have been discussed in a joint publication. (Hubble and Isbell 1958.)

An aeolian hypothesis is supported to a certain extent by the fact that there are small sandy areas scattered throughout the region, normally without any apparent pattern or orientation. All of these are slightly elevated and some consist of quite deep loose sand. It seems likely that these represent old sand dunes, now fixed or " dead " and usually carrying considerable vegetation. These may have formed during periods in the Pleistocene or early Recent when conditions were much more desiccated than they are to-day. Aeolian agencies were probably predominant in their genesis although some of the larger sand deposits in the vicinity of the Weir River and other streams were doubtless partly formed by stream action.

In the south of the region, especially between the Macintyre and Weir Rivers, in an area still subject to flooding, there is a wide sheet of clay alluvium that is very different to the clay materials discussed above. This was doubtless largely formed during some pluvial stage of the Pleistocene when the rivers were carrying greater quantities of water and contained sediments, than they are to-day.

4.—Notes on the Geological Map.

In the region under discussion outcrops of the sedimentary rocks are few and often widely separated. Thus to delineate formational boundaries it is often necessary to invoke the aid of evidence other than that of a strictly geological nature. Quite frequently the soils of an area directly or indirectly indicate the nature of the underlying rocks while in most instances aerial photograph patterns are extremely useful in defining geological boundaries.

Another major problem is that nearly all sediments have been affected to varying degrees by lateritic influences so that in many areas—the " laterite " formation on the map, it is impossible to decide the age and often the nature of the original sediments. This also leads to difficulty in differentiating these areas from suspected Blythesdale outcrops. Finally there are the vast sheets of dominantly clay soils that form a superficial cover over the greater part of the region. Although shown on previous maps as Tertiary it appears far more likely that these represent Quaternary developments while the youngest formation shown on the map—the alluvia, is still receiving fine sediments from present day high floods.

V.—VEGETATION OF THE REGION.

The vegetation of the region has not previously been separately discussed. Blake (1938) has dealt with the western areas of Queensland and many of his communities are present in this region. The vegetation of the area immediately south of the New South Wales border has been described in the preliminary surveys of the resources of the Namoi Region (1950) and the New England Region (1951) while Beadle (1948) has dealt exhaustively with western New South Wales. It is emphasised that the following discussion of the vegetation is not intended to be a detailed ecological or systematic botanical survey. The vegetation has mainly been studied with regard to its relationships with the various soil associations but as a considerable amount of information regarding the various plant communities has been thus assembled it was thought desirable to present it as a separate section. As there rather tends to be a lack of uniformity in Australian ecological nomenclature some difficulty was experienced in this regard but in the main the concepts and nomenclature of Beadle (1948) have been largely followed. Common names of grasses and other herbaceous plants conform where possible to the C.S.I.R.O. " Standardised Plant Names " (1953).

There is only a difference of some five inches in average rainfall between the wetter and drier parts of the region and temperature conditions are fairly uniform throughout. Hence climatic factors do not appear to play a major role in influencing the vegetation within the region itself. The occurrence of an appreciable winter component in the rainfall is responsible for the presence of some winter annual herbaceous species but does not appear to be reflected in the composition of the major plant communities. The amount of moisture available to the plant is of prime importance and this is governed by both soil texture and horizon arrangement as well as by surface drainage conditions. Due to the topographic uniformity of much of the region this factor is only important in so far as it affects local surface drainage. Other important factors influencing the vegetation are the fertility status and more important still the degree of salinity of many of the soils. In general then there is a fairly close relationship between the nature of the soils and the plant communities although there are few individual species that may be regarded as indicators of any single or a set of edaphic factors.

The region has been fairly closely settled for a considerable period of time and it is often difficult to assess the effect of the various biotic factors on the plant communities as they exist to-day. Certainly in many cases the effect has been pronounced. Much of the region was originally heavily timbered but large areas have been cleared or partly cleared so that numerous artificial communities are now present. The effect of grazing animals—mainly sheep with some cattle but also up until very recent years including a large rabbit population—has had considerable effect more particularly on the herbaceous elements of the vegetation. Fire and drought are other factors that have doubtless played a part in the present composition of the communities. In the following description of the major communities it has not been possible to assess the biotic factor to any extent other than the effects of land clearing and overgrazing. Thus the vegetation is discussed in terms of natural communities which, however, have been influenced to some extent by various biotic factors, and the artificial communities which have largely resulted from land clearing involving removal of all or most of the original timber cover.

1.—Natural Communities.

The vegetation is discussed in terms of the more important communities without any serious attempt to define these in terms of structural units. However, to facilitate description the communities may be grouped into the four broad formations of dry sclerophyll forest, brigalow-belah forests, woodland and parkland (savannah). In addition, some important miscellaneous communities are described.

(a) Dry Sclerophyll Forest.

These communities classed as forest vary somewhat in structure. The canopy may or may not be continuous while there is a variable development of a shrub layer. The term " tall woodland " of Beadle (1948) is probably more appropriate for the cypress pine–bull oak communities. These forests have their greatest development in the eastern part of the region where they mainly occur on impoverished soils derived from the sandstones of the Blythesdale Group. Many quite distinctive communities are present and their distribution is closely related to the nature of their supporting soils.

(i.) *Cypress Pine–Bull Oak Communities*—

These are the most clearly defined communities and whether cypress pine (*Callitris glauca*) or bull oak (*Casuarina leuhmannii*) assumes dominance is almost entirely decided by the nature of the soil. Where cypress pine is dominant (often in almost pure stands) the soils are solods, solodic or solodized-solonetz with a sandy A horizon usually exceeding twelve inches in depth. With a shallower A horizon and a heavier texture—on typical solodized-solonetz soils, bull oak increases in importance and may occasionally form pure stands.

In both the cypress and bull oak forests associated tree species are also prominent. Most common are poplar box (*Eucalyptus populnea*), narrow leaved ironbark (*E. crebra*), rusty gum (*Angophora costata*) and tumble down gum (*E. dealbata*). The associated shrub layer is usually not prominent although on the sandy areas *Acacia conferta* may be common while occasionally *A. spectabilis, A. mollissima, Hovea longifolia, Melichrus urceolatus* and a wild hop *Dodonaea cuneata* may occur. In the denser forests there is only a sparse ground cover, the chief species being the wire grasses *Aristida caput-medusae* and *A. ramosa*, the love grasses *Eragrostis leptostachya* (paddock love grass), *E. elongata* and *E. lacunaria* (purple love grass), and golden beard grass (*Chrysopogon fallax*). In the bull oak forests along the Crowder Creek road south of Tara *Gahnia aspera* forms a sparse ground cover.

While these cypress pine-bull oak communities have their greatest development in the eastern part of the region there are other lesser developments further west, in particular along the Moonie Highway and west of the Weir River in the vicinity of Goodar. In these areas kurrajong (*Brachychiton populneum*), quinine berry (*Petalostigma pubescens*) and narrow leaved ironbark are common, with occasionally the bloodwood *Eucalyptus trachyphloia* and red ash (*Alphitonia exclesa*).

(ii.) *Poplar Box–Narrow Leaved Ironbark Community*—

This community is developed on some areas of less strongly solonised soils throughout the Blythesdale and Bundamba sandstone region and except where the soils are shallow and stony bull oak is the most common associated species. In such a community north-west and south-east of Inglewood there is often a dense shrub layer developed which includes *Melaleuca nodosa, Acacia triptera,* and a low wattle (*A. doratoxylon var. angustifolia*). Associated sandy areas carry cypress pine, red ash (*Alphitonia exclesa*) and thready bark oak (*Casuarina inophloia*). In other areas such as south of Inglewood along the Texas road on soils characterised by a gravelly surface this poplar box-narrow leaved ironbark community has silver leaved ironbark (*Eucalyptus melanophloia*), mallee box (*E. pilligaensis*) and bull oak as associated species together with a fairly dense shrub stratum of *Acacia ixiophylla, Melaleuca nodosa* and *M. decora*. Throughout these poplar box-narrow leaved ironbark communities there is a sparse ground cover of wire grasses (*Aristida spp.*) and love grasses (*Eragrostis spp.*).

(iii.) *Mallee Box–Poplar Box Community*—

On the solonised soils along Brush Creek south of Inglewood there is a community dominated by mallee box (*E. pilligaensis*) with poplar box (*E. populnea*) usually associated and occasionally co-dominant. Narrow leaved ironbark (*E. crebra*) is also often present.

Plate 5.
Cypress pine forest on acid sandy solodized soils 8 miles east-north-east of Yelarbon.

Plate 6.
Bull oak forest growing on clay loam surfaced solodized-solonetz soils adjacent to the Moonie Highway near the Tara turn-off. These soils are of very low fertility.

(iv.) *Tumbledown Gum–Cypress Pine Community*—

On the shallow stony ridges derived from the Palaeozoic rocks south of Inglewood a community dominated by tumbledown gum (*E. dealbata*) and cypress pine is prominent. Both poplar and mallee box and narrow leaved and silver leaved ironbark also occur.

(v.) *Lancewood Communities*—

On shallow sandstone and lateritic soils along the Moonie Highway near Parkhurst and further west there are small localised communities of lancewood (*Acacia sparsiflora*) with associated narrow leaved ironbark (*E. crebra*), red ash (*Alphitonia exclesa*) and occasional bull oak (*Casuarina luehmannii*), together with the shrub *Acacia spectabilis*. The ground flora is sparse, consisting mainly of *Eriachne mucronata, Eragrostis lacunaria* and *Aristida caput-medusae*.

(vi.) *Wattle Communities*—

These form low forests which are chiefly developed on stony lateritic outcrops within the Blythesdale sandstone region and around Glenmorgan. The chief species is *Acacia cunninghamii* but other unidentified wattle species are normally present. Narrow leaved ironbark, poplar box and less commonly cypress pine are the chief associated species. The ground flora is sparse and usually consists of *Aristida caput-medusae* and the love grasses (*Eragrostis spp.*)

(*b*) Brigalow–Belah Forests.

Brigalow-belah forests are widespread throughout the region with the exception of the sandy forest areas in the east and the parkland region in the south-west. These brigalow-belah communities are popularly referred to as scrubs in most cases but this is not in conformity with the ecological use of the word. Especially where belah is prominent the communities are more correctly referred to as a forest as both the brigalow (*Acacia harpophylla*) and the belah (*Casuarina lepidophloia*) may frequently exceed fifty feet in height.

Almost without exception throughout the region the brigalow-belah communities are developed on deep clay or clay loam surfaced soils which vary from shades of grey and brown to an occasional red-brown. A feature of these soils is that although they are normally alkaline in their upper levels almost invariably the deeper subsoils are strongly acid while some profiles may be acid throughout. Another almost constant feature where brigalow is a prominent member of the community is the presence of a strong gilgai microrelief with some of the depressions ranging up to five feet in depth. (Plates 17, 18.)

The brigalow-belah forests of this region may be divided into three fairly distinct communities, almost pure brigalow, mixed brigalow-belah and almost pure belah.

(i.) *Almost Pure Brigalow Communities*—

Almost pure stands of brigalow of any extent are rare in this region but where they do occur they approach a true scrub in structure with frequently a dense lower story of " whipstick " suckers. The chief occurrences are between Meandarra and Glenmorgan and south-east of Meandarra along The Gums road. (Plate 7). However, even in these areas there are usually isolated trees of belah and wilga (*Geijera parviflora*), with also especially towards Glenmorgan, some scattered small clumps of poplar box (*Eucalyptus populnea*) and occasionally yapunah (*E. thozetiana*). The soils of these almost pure brigalow stands are heavy grey clays and are invariably strongly gilgaied. All have strongly acid subsoils and most are acid throughout.

(ii.) *Mixed Brigalow–Belah Communities*—

By far the most common over the greater part of the region and especially so in the northern half are brigalow-belah forests (Plate 8), in which either species may assume dominance. Almost invariably occurring as lower story associates are wilga (*Geijera parviflora*) and sandalwood (*Eremophila mitchellii*) while in some areas limebush (*Eremocitrus glauca*), fuchsia bush (*Eremophila *maculata*), true sandalwood (*Santalum lanceolatum*) and black tea-tree (*Melaleuca pubescens*) may be common. The latter is most frequent north and north-west of Yelarbon and south of Tara. Less common associated species include poplar box and bottle tree (*Brachychiton rupestrie*).

The soils of this community range from grey and brown clays to occasional brown or grey-brown clay loams. It has been observed that there is usually a fairly close relationship between soil type, degree of gilgai development and the extent to which belah dominates the community. This will be discussed later but it may be noted here that where the belah tends to dominance the soils tend to brownish types often with a clay loam surface and the degree of gilgai development becomes much less.

(iii.) *Almost Pure Belah Communities*—

Almost pure stands of belah forest are quite common scattered throughout the region and especially so in the southern central part of the area north of Goondiwindi. (Plates 9, 10). In some stands brigalow may be virtually absent but wilga, sandalwood and less commonly poplar box are the usual associates. In many cases limebush is prominent while occasionally emu apple (*Owenia acidula*) and wild orange (*Capparis mitchellii*) occur sparingly. The soils of the belah communities are characterised by a clay loam surface and usually by an absence of gilgai. Colour may range from grey-brown to brown and even red-brown.

The ground cover in most of these brigalow, brigalow-belah and belah communities is fairly sparse. Prior to the introduction of *Cactoblastis* these forests were densely infested with prickly pear (*Opuntia spp.*) but this infestation has now been virtually completely destroyed. Small shrubs and herbaceous plants are common in most areas, the more important being currant bush (*Carissa ovata*), *Rhagodia parabolica*, prickly roly poly (*Salsola kali*), *Bassia quinquecuspis* and *B. tetracuspis*, the creeping saltbush *Atriplex semibaccata*, fishweed (*Chenopodium trigonon*) and cotton bush (*Kochia tomentosa var. brevifolia*). In all but the more open forests the gramineous flora is rather sparse, mainly consisting of the brigalow grasses *Paspalidium caespitosum* and *P. gracile*. In damper situations such as in and around gilgais the sedges *Carex rhytidocarpa* and *Cyperus retzii* are common, together with *Diplachne parviflora*, nardoo (*Marsilea drummondii*) and occasionally cane grass (*Leptochloa digitata*). In the more open forest communities species of *Chloris* may be common as well as the brigalow grasses, chiefly *C. acicularis*, *C. truncata* and *C. divaricata*. Fairy grass (*Sporobolus caroli*), paddock love grass (*Eragrostis leptostachya*) and weeping love grass (*E. parviflora*) may occasionally be prominent. In some years there may be a winter-spring growth of small woolly burr medic (*Medicago minima*), less commonly burr medic (*M. denticulata*), and the yellow flowered annual *Senecio platylepsis*.

The total area of these brigalow and belah communities in the region is some 2·8 million acres, of which nearly a million acres is dominantly belah. However, some 1·8 million acres of the total area has now been cleared and these cleared areas are shown on the map of the brigalow and belah lands. This clearing has resulted in various artificial communities which are discussed later.

(c) Woodland Communities.

Although there are fewer large well defined areas of woodland than the previous formations there do exist communities that are characterised by fairly well spaced tree species and often by a prominence of shrub species and low trees. Some communities are quite distinctive in structure while others are merely transitional to forest formations. Those discussed below almost invariably possess the characteristics of a woodland community.

(i.) *Poplar Box–Sandalwood–Wilga Community*—

This community is almost invariably present on the weakly solodized-solonetz soil association and on the red-brown earths. The poplar box (*E. populnea*) usually occurs as fairly tall trees of varying density while the much lower sandalwood (*Eremophila mitchellii*) and wilga

Plate 7.

Low forest consisting of an almost pure stand of brigalow, south-east of Meandarra. The soils are the typical gilgaied greyish-brown clays which here are acid throughout the profile.

Plate 8.

Mixed brigalow-belah forest with an understorey of wilga, approximately 15 miles north of Goondiwindi. The gilgaied clay soils here are alkaline in their upper levels but the subsoils are strongly acid.

[Lands Department photo.]

Plate 9.

Belah forest 3 miles west of the Weir River on the Goondiwindi-Lundavra road. An understorey of wilga and sandalwood is normally present. These belah forests are widespread in the region.

Plate 10.

Inside the belah forest above showing the almost complete absence of any ground cover, only fallen leaf litter being present. The soils are the weakly solonised brown clay loams.

[G. W. Tweedale, photo.]

(*Geijera parviflora*) may often be closely spaced. Frequently much of the sandalwood is dead (Plate 22). Common associated species include whitewood (*Atalaya hemiglauca*), ironwood (*Acacia excelsa*), belah (*Casuarina lepidophloia*), limebush (*Eremocitrus glauca*) and wild orange (*Capparis mitchellii*), with occasionally leopard wood (*Flindersia maculosa*) and *Cassia circinata*. Small shrubs as a rule are not common although in some areas galvanised burr (*Bassia birchii*) may be abundant, due mainly to overgrazing. The ground flora is normally fairly continuous, the chief species being slender Chloris (*Chloris divaricata*), windmill grass (*C. truncata*) and curly windmill grass (*C. acicularis*) with occasionally fairy grass (*Sporobolus caroli*) and Queensland blue (*Dichanthium sericeum*). On sandier areas some wire grasses (*Aristida spp.*) and love grasses (*Eragrostis spp.*) may be found. Also common in this community is bogan flea (*Calotis hispidula*) while in some years the annual winter medics *Medicago minima* and *M. denticulata* (burr medic) may be prominent although the latter is normally only found towards the south of the region.

(ii.) *Myall–Boonarie Communities*—

On the heavy grey clays in the south-west of the region and also but less commonly on the undulating parkland region around Coomrith there are low woodland communities dominated by myall (*Acacia pendula*) and usually accompanied by boonarie (*Heterodendron oleifolium*) with some coolibah (*E. microtheca*). A few associated small shrubs may occur, chiefly fuchsia bush (*Eremophila maculata*), while a tussock grass cover is generally present, chiefly curly mitchell (*Astrebla lappacea*).

(iii.) *Poplar Box–Silver leaved Ironbark–Apple Community*—

This taller woodland community is developed on the alluvial soils along Macintyre Brook, the Macintyre River as far downstream as Goondiwindi, and parts of the Weir River. Apple (*Angophora intermedia*) is rather less common than the other two major species while narrow leaved ironbark (*E. crebra*), flooded gum (*E. camaldulensis*) and coolibah (*E. microtheca*) also occur. A shrub layer is usually not developed although there may be isolated plants of the cotton bush (*Kochia tomentosa var. brevifolia*) and on some areas of poorer soil galvanised burr may be common. There is usually quite a dense grass cover, the chief species being pitted blue (*Bothriochloa decipiens*), slender bamboo grass (*Stipa verticellata*) and species of *Aristida*. Other species that may occur include golden beard grass (*Chrysopogon fallax*), forest blue (*Bothriochloa intermedia*), Queensland blue (*Dichanthium sericeum*), and species of *Chloris*. Along the Weir River south of Goodar a few plants of black spear (*Heteropogon contortus*) have been found. In years of good winter rainfall along these alluvial flats there may be quite a dense sward of burr medic (*Medicago denticulata*) and the associated small woolly burr medic (*M. minima*).

(iv.) *Silver Leaved Ironbark–Poplar Box–Narrow Leaved Ironbark Community*—

The fairly small areas of lateritic red earths that are scattered throughout the region support a typical woodland community of *E. melanophloia*, *E. populnea* and *E. crebra*. Where the soils tend to be shallow and stony cypress pine may often be prominent. Other species which may occur include ironwood (*Acacia excelsa*), nelia (*A. oswaldii*), sandalwood (*Eremophila mitchellii*) and bull oak (*Casuarina leuhmannii*). The ground cover consists of the wire grasses *Aristida jerichoensis*, *A. echinata*, *A. ramosa* and *A. caput-medusae*, occasionally kangaroo grass (*Themeda australis*), also *Neurachne xerophila* and *Eragrostis molybdea*.

(*d*) Parkland Communities (Savannah).

Due to the term savannah often being rather loosely used the term parkland is preferred to refer to certain communities which may be quite treeless and approach true grasslands but usually possess scattered trees or clumps of timber. These occur in the south-west of the region between the Macintyre and Weir Rivers and also in the north-west around Coomrith.

(i.) *Coolibah–Boonarie–Myall–Mitchell Grass Community*—

This community occurs on the heavy grey clays in the south-west of the region and may range in density of tree species from parkland to almost true grassland. Coolibah (*E. microtheca*) and boonarie (*Heterodendron oelifolium*) are invariably present throughout as scattered trees but the myall (*Acacia pendula*) and in some areas belah (*Casuarina lepidophloia*) rather tend to be segregated into fairly well defined clumps. The shrub layer of the community is either poorly developed or absent, where present the chief species are fuchsia bush (*Eremophila maculata*), with less commonly *E. bignoniiflora.* In wetter situations river wattle (*Acacia stenophylla*) and clumps of lignum (*Muehlenbeckia cunninghamii*) may occur.

There is almost invariably a continuous tussock grass cover throughout the community (Plate 15). In most areas this is dominated by curly mitchell (*Astrebla lappacea*) but other species are also widespread. The chief of these include Queensland blue (*Dichanthium sericeum*), small Flinders (*Iseilema membranaceum*) native millet (*Panicum decompositum*), shot grass (*Paspalidium globideum*), button grass (*Dactyloctenium radulans*), early spring grass (*Eriochloa pseudoacrotricha*), brown top (*Eulalia fulva*), species of *Chloris*, forest blue (*Bothriochloa intermedia*) and water grass (*Thellungia advena*). Other plants that may occur include a Darling pea (*Swainsona sp.*) and Sesbania pea (*Sesbania benthamiana*) while downs nut grass (*Cyperus retzii*) is very common on areas subject to flooding. In some years there may be a good development of the winter medics *M. denticulata* and *M. minima.*

(ii.) *Other Parkland Communities*—

On the undulating clay soils developed on marine Cretaceous sediments in the north-west of the region different parkland communities are developed but here they are not so well defined. Usually on the brown and reddish-brown soils of the crests of the ridges and their upper slopes there is a silver leaved ironbark-poplar box community, further down the slopes on grey soils coolibah (*E. microtheca*) and myall (*Acacia pendula*) are more prominent, usually with the exclusion of silver leaved ironbark (*E. melanophloia*). On lower flatter areas between the ridges a coolibah-myall community is developed on grey clay soils but occasionally clumps of sandalwood (*Eremopohila mitchellii*) and wilga (*Geijera parviflora*) occur where the soils are red-brown earths. Around the margins of these communities scattered clumps of brigalow and belah may be common.

There is normally a continuous grass cover throughout these communities, the dominant species is Queensland blue (*Dichanthium sericeum*) but forest blue (*Bothriochloa intermedia*), *Panicum decompositum* and *Aristida latifolia* also occur. On the slopes of some of the ridges where linear gilgai is prominent *Dichanthium sericeum* is confined to the depressions while the puffs are occupied by a rather small form of *Aristida latifolia.* Darling pea (*Swainsona sp.*) is often fairly common while *Chloris divaricata* and *C. truncata* are also usually present.

(*e*) Miscellaneous Communities.

(i.) *Tea-tree-Spinifex Community*—

An interesting *Melaleuca adnata-Triodia irritans* community is developed on the so-called " desert " area surrounding Yelarbon (Plate 11). It is quite evident that the factors responsible for this community are edaphic ones ; the soils are highly alkaline solonetz and solodized-solonetz and much of the area presents a scalded claypan-like appearance due to erosion (apparently mainly by wind) of the surface soil horizons. (Plate 27).

The spinifex does not form a continuous ground cover but rather is confined to fairly large separate clumps often separated by bare areas where the surface soil has been eroded away. The *Melaleuca adnata* is always stunted in habit and may occur singly or in small thickets. Also fairly common is low sandalwood (*Eremophila mitchellii*), much of which is dead. This general stunted aspect of the community is quite characteristic but isolated tree species do occur, mainly

Plate 11.
View of the Yelarbon "desert" showing the impoverished vegetation of spinifex, tea-tree and bull oak developed on the highly alkaline solonetz soils.

Plate 12.
The result of overgrazing on the marginal soils of the Yelarbon "desert", the ground cover now consisting entirely of *Bassia tricuspis* and *Salsola kali*. Originally a sparse growth of *Chloris* spp. was present.

bull oak (*Casuarina luehmannii*), poplar box (*E. populnea*) and mallee box (*E. pilligaensis*). Usually there is little ground cover apart from the spinifex although in areas where the top soil has not been removed there is a sparse growth of *Chloris divaricata* and *C. truncata*. Where areas have been overgrazed there may be a dense growth of *Bassia tricuspis* and *Salsola kali* (Plate 12).

The boundry of this typical " desert " community is usually not sharp except in the south. Where it merges into the surrounding brigalow and belah areas there is a narrow marginal zone in which there is very little, if any, spinifex and much less tea-tree but an influx of stunted brigalow and belah. Bull oak is still fairly common, also sandalwood and poplar box. There is again little grass developed except for scattered areas of *Chloris divaricata* and *C. truncata* with in overgrazed areas an often almost complete ground cover of *Bassia tricuspis* and *Salsola kali*.

(ii.) *Narrow Leaved Ironbark-Spinifex Communities*—

Triodia irritans communities are also known in other parts of the region. Around Brush Creek south of Inglewood on the Beebo road there is a small area of a spinifex community with associated narrow leaved ironbark and some stunted bull oak and tea-tree (*Melaleuca adnata*). The soils of this area are again strongly solonised and here have a stony rubble surface. (Plate 26.)

Ten miles east of Tara along the railway line there is a further occurrence of spinifex, here associated with narrow leaved ironbark and *Melaleuca nodosa*. In some of the bull oak forests, particularly those containing associated narrow leaved ironbark, there are small scattered occurrences of *Triodia irritans*. Such an occurrence is found along the Crowder Creek road after it leaves the Moonie Highway south of Tara, while east of Tara there are scattered plants of spinifex associated with a small *Xanthorrhoea*.

(iii.) *Sandalwood-Wilga-Tea Tree-Disphyma australe Community*—

Adjoining the Yelarbon " desert " some three miles east-north-east of Yelarbon there is an interesting community of small extent developed. Here the soils are not so strongly solonised and a low shrub woodland of sandalwood, wilga, *Melaleuca adnata* and *Anthobolus leptomerioides* is developed with again much of the sandalwood being dead. The unusual feature of this community is that the ground over an area of several acres at least is almost completely covered with the fleshy pigface-like plant, *Disphyma australe*.

(iv.) *The Sandridge Communities*—

Scattered throughout the region are sandridges of variable but usually small extent. These are of two general types, a deep elevated sandridge of limited extent and particularly common in the south-west of the region and more extensive, shallower and only very slightly elevated occurrences which are particularly common in the central part of the region between the Moonie and Weir Rivers.

The deep elevated sandridges (Plate 23) carry a distinctive community of tumbledown gum (*Eucalyptus dealbata*), Moreton Bay ash (*E. tessellaris*), cypress pine (*Callitris glauca*), ironwood (*Acacia excelsa*) and poplar box (*E. populnea*) with occasionally bitter bark (*Alstonia constricta*) and a bloodwood (*Eucalyptus polycarpa*). The grass cover is sparse due to the very loose sandy nature of the soil and the chief species are inferior grasses such as *Aristida echinata* and *Eragrostis speciosa* and the yellow flowered annual *Podolepis longepedunculata*. On a sandridge north-north-west of Yelarbon blady grass (*Imperata cylindrica var. major*) is associated with *Aristida spp*. Also on this sandridge a fairly tall *Xanthorrhoea* occurs while rusty gum (*Angophora costata*) is prominent in the tree species (Plate 24).

On the shallow surface solonised soils which often form a narrow fringing zone around these sandridges there is sometimes a dense mallee-like growth of *Eucalyptus dealbata*.

The other much less elevated and generally more extensive sandridges have a tough clay horizon at depths not usually exceeding four feet and frequently much less. These areas almost invariably have a fairly dense cypress pine-bull oak community that may approach a forest in structure. Associated tree species are rusty gum (*Angophora costata*), *Eucalyptus dealbata* and *E. populnea*. Occasionally such as in the vicinity of The Gums *E. dealbata* may be the dominant species. There is usually a well developed shrub layer with *Acacia conferta, A. spectabilis, Dodonea cuneata* and *Hovea longifolia* most prominent. The grass cover is fairly sparse with species of *Aristida* and *Eragrostis* most common.

(v.) *Fringing Forests*—

Along most of the major watercourses of the region there is a narrow fringe of tall trees. On the lower reaches of the Macintyre, Weir and Moonie Rivers this is composed almost entirely of coolibah (*Eucalyptus microtheca*) (Plate 3) with occasionally some flooded gum (*E. camaldulensis*) and river wattle (*Acacia stenophylla*). In the upper reaches of these streams and along Macintyre Brook where in general the watercourses flow through more sandy country the fringing forest is more likely to be dominated by *E. camaldulensis* although *E. microtheca* is still prominent.

2.—Artificial Communities.

Over large areas of the region much of the original timber cover has been either cleared or partly cleared by various means such as ringbarking and burning, mechanical clearing or, in recent years, aerial spraying with hormone weedicides. This has resulted in various artificial semi-grassland communities being developed.

(i.) *Communities of Cleared Brigalow and Brigalow-Belah Forests*—

Ever since attempts were first made to clear brigalow country trouble has been experienced with brigalow sucker regrowth. Uncontrolled burning has frequently resulted in a dense regrowth that may leave the land with a far heavier timber or shrub cover than it originally possessed. Belah does not constitute a regrowth problem although some seedlings may develop, but when the original scrub contained black tea-tree (*Melaleuca pubescens*), limebush (*Eremocitrus glauca*) and sandalwood (*Eremophila mitchellii*) these may be troublesome and form an often fairly dense cover of low shrubs. (Plate 13).

However, initially following clearing of brigalow country a fairly dense annual herbaceous community develops. The more important species include *Zygophyllum apiculatum* (twin leaf), *Lepidium sagittulatum, Cirsium vulgare* (spear thistle), *Solanum laciniatum, Chenopodium trigonon* (fishweed), *Salsola kali* and usually some bathurst burr (*Xanthium spinosum*). Other small herbaceous plants often present include *Helipterum polyphyllum, Helichrysum bracteatum, Bassia tetracuspis*, creeping saltbush (*Atriplex semibaccata*) and the yellow flowered winter annual *Senecio platylepsis*.

In the first year following clearing there is normally little growth of grass. The first species to colonise are usually species of *Chloris*, generally accompanied by the brigalow grasses *Paspalidium gracile* and *P. caespitosum* and fairy grass (*Sporobolus caroli*). At a later stage Queensland blue (*Dichanthium sericeum*), early spring grasses (*Eriochloa spp.*) and weeping love grass (*Eragrostis parviflora*) may become prominent while the winter medic (*Medicago minima*) may be common in favourable seasons. However, this general succession may be modified depending on time of clearing and following seasonal conditions.

(ii.) *Communities of Cleared Belah Forests*—

Although the brigalow regrowth problem is usually not encountered cleared belah country is often characterised by a regrowth of poplar box, limebush and sandalwood. This regrowth if unchecked may lead to the development of a fairly tall and close community of completely different aspect from the original belah forest. The herbaceous flora developed after clearing is

Plate 13.

Cleared brigalow country near Yelarbon now with a prominent regrowth of brigalow, black tea-tree (left) and lime bush (centre foreground).

Plate 14.

Clumps of young belah invading a poplar box-sandalwood woodland community along the upper reaches of the Moonie River. This belah invasion appears to be occurring in many parts of the region.

similar to that of cleared brigalow land although it would appear that grass species become established more quickly. These are again the usual *Chloris* species (*C. truncata* and *C. divaricata* chiefly), *Sporobolus caroli*, the brigalow grasses (chiefly *Paspalidium gracile*) with later *Dichanthium sericeum*, species of *Eriochloa* and *Eragrostis* and some winter medics.

(iii.) *Communities of Cleared Cypress Pine-Bull Oak Forests—*

Only limited areas of forest have been cleared, the main area being west of the Weir River in the vicinity of Goodar where an artificial grassland community is dominated by *Aristida echinata*, *Eragrostis molybdea* and a tall kangaroo grass (*Themeda australis.*) Also common is comet grass (*Perotis rara*) and the yellow flowered annual *Podolepis longepedunculata*.

(iv.) *Communities of the Stock Routes and Road Enclosures—*

The stock routes usually suffer from heavy overgrazing so that more palatable grasses tend to become replaced by inferior species such as *Aristida* and in some places bare scalded areas may develop. Galvanised burr (*Bassia birchii*) may become very common while along the Macintyre Brook alluvials in particular cotton bush (*Kochia tomentosa var. brevifolia*) is prominent. Around Goondiwindi there are some localised occurrences of African boxthorn (*Lycium ferocissimum*). A feature of some stock routes and especially road enclosures after winter rains is the often prolific growth of burr medic (*Medicago denticulata*) while in the summer months there may be a heavy growth of feather top Rhodes (*Chloris virgata*).

3.—Some Community Relationships and their effect on Soil Formation.

One of the most clearly defined features of the vegetation of the region is that the belah communities are slowly but surely extending their range. Belah is quite clearly at present invading the poplar box-sandalwood-wilga communities, mainly on the weakly solodized-solonetz clay loams but also on the solonised red-brown earths. Evidence of this may be seen in many areas where isolated trees and clumps of young belah are found within the box-sandalwood-wilga communities (Plate 14) and in many of the belah forests there are large box trees, many of them now dead. With this encroachment of belah there is a marked diminution in the gramineous ground cover, often to the stage reached in the denser belah forests where it is almost absent, the ground merely being covered with fallen leaf litter (Plate 10).

It would also appear that this belah invasion has resulted in soil changes. There are few observable differences in soils supporting a thicket of belah and surrounded by a box-sandalwood community but where a large stand of belah obviously of considerable age is suspected of having previously replaced a box-sandalwood-wilga community soil differences are more apparent. The A horizon is often shallower and the B horizon is not as tough and massive as in the box-sandalwood soils. A slight tendency towards shallow gilgai formation may be noticeable.

An entirely different tendency for vegetation to influence the nature of the soil is observed in those areas where an originally dense belah forest has been cleared for periods of some fifty years or more. Where induced grassland conditions have been prevailing for such a period there is a tendency for the soil to change to a black earth type. The surface soil becomes darker in colour (presumably due to increased organic matter), a tendency towards a granular self-mulching structure becomes apparent and the A horizons are much less sharply differentiated than in the typical soils under a belah forest. These soil changes are not altogether unexpected as there is a complete environmental change from a shaded dense forest floor with a sparse gramineous ground cover to an open grassland community with closely spaced plants.

A much more difficult question to decide is whether the brigalow communities are extending their range. Many old residents claim that there has been a noticeable brigalow invasion within living memory but these matters are difficult to prove or disprove. At present there appears to be little if any clear evidence of brigalow invading other communities. There are examples of clumps of young brigalow trees surrounded by a poplar box-sandalwood-wilga woodland and in many of the brigalow forests there are large box trees and old stumps. However, it is difficult to evaluate the many factors that could be responsible for such phenomena.

An interesting feature common in this region as well as elsewhere in various parts of Queensland is the occurrence of numerous clumps or isolated trees of sandalwood (*Eremophila mitchellii*) the majority or all of which are now dead (Plate 22). The reason for this is not yet clear. It is agreed that in many cases the dead sandalwood has been growing on rather droughty solonised soils of low fertility but in many areas of Queensland this is the usual environment of the species. A possible explanation may be that in extreme drought years the poor moisture penetration and retention of the soil together with the general low fertility and often high salt content may produce stress conditions that result in the death of the tree.

VI.—CLASSIFICATION AND DESCRIPTION OF THE SOILS.

In this region of 8,500 square miles there is a variety of soils representative of many of the great soil groups and in addition some which cannot readily be assigned to any of the established great soil groups. The soils of the region have not previously been systematically mapped or described although for some areas there was a limited amount of unpublished data available from the Queensland Department of Agriculture and Stock and unpublished work by P. J. Skerman, formerly of the Bureau. Broad reconnaissance mapping at a scale of one to a million of the north-eastern part of the region has recently been completed by the C.S.I.R.O. Division of Soils while the soils of the areas immediately south of the New South Wales border have been mapped and described at the association level in the preliminary surveys of the resources of the Namoi (1950) and New England (1951) regions.

1.—Mapping Technique and Classification.

(a) MAPPING TECHNIQUE.

The complex nature and distribution of many of the soils encountered, together with the fact that the survey is largely of a reconnaissance nature dealing with a rather extensive area, necessitated a fairly broad grouping of the soils into convenient mapping units. As in all surveys the choice of mapping units had to be governed by several considerations ; firstly, in this case taxonomic units recognisable on the ground could not always be distinguished on aerial photographs so that for this reason alone each taxonomic unit recognised could not be set up as a mapping unit. It remained then to consider as possible mapping units those taxonomic units or combinations thereof that could be readily recognised both on the ground and on aerial photographs. The second consideration involved limitations imposed by the scale of the final map, in this case four miles to an inch. This necessitated the combining of some definable taxonomic units into mapping units appropriate to the scale of the map.

The taxonomic units were in general selected at the great soil group level although in some cases units at a lower level of generalisation were distinguished. These taxonomic units were combined into mapping units by grouping those taxonomic units which were more or less regularly associated geographically in a usually definable proportional pattern. This grouping, by definition (United States Soil Survey Manual 1951), constitutes a soil association so that in general the mapping units adopted are associations at the great soil group level. However, in some cases, chiefly because of potential agricultural importance or particular ease of differentiation, units lower than that of a great soil group were defined as an individual soil association. Thus, the solodized-solonetz soils, accepted as a great soil group, have been subdivided on the basis of major morphological features into several sub-groups which have been made members of different associations.

The associations normally have a particular great soil group as their dominant constituent with other great soil groups occurring in minor proportions. However, while the ratio between dominant and associated soils is usually relatively constant it is only to be expected that over large areas there will be some fluctuation in the proportion of the unit occupied by the associated minor soils and also in their constitution. The important fact is that in nearly all instances the dominant great soil group member consistently occupies the greater proportion of the area.

TABLE 10.

THE RELATIONSHIP BETWEEN THE MAPPING UNITS AND THEIR DOMINANT GREAT SOIL GROUP CONSTITUENT.

—	Mapping Unit.	Appropriate or Related Great Soil Group of Dominant Constituent.
Group 1	Recent alluvial Soil Association	Alluvial Soils (Regosols* in part), Submature Red-Brown Earths
Group 2	Grey Soil of Heavy Texture Association ..	Grey and Brown Soils of Heavy Texture.
Group 3	Grey and Brown Soil of Heavy Texture Association	
Group 4	Grey Clay Association	Closely related to Grey and Brown Soils of Heavy Texture.
Group 5	Brown Clay Association	
Group 6	Weakly Solonised Brown Clay Loam Association	Weakly solonised soils related to Grey and Brown Soils of Heavy Texture, Red-Brown Earths and Solodized-Solonetz
Group 7	Weakly Solodized-Solonetz Association	
Group 8	Red-Brown Earth Association	Red-Brown Earths (weakly solonised)
Group 9	Lateritic Red Earth Association	Lateritic Red Earths (Latosols* in part)
Group 10	Deep Sands Association	Regosols* (slightly solonised)
Group 11	Sandy Solod-Solodic-Solodized-Solonetz Association	Solod, Solodic, Solodized-Solonetz
Group 12	Sandy Solodic Association	Solodic
Group 13	Solodized-Solonetz Association	Solodized-Solonetz
Group 14	Stony Solodized-Solonetz Association	
Group 15	Solonetz-Solodized-Solonetz Association ..	Solonetz, Solodized-Solonetz
Group 16	Lithosols derived from Sandstone and Lateritic Material	Lithosols*
Group 17	Lithosols derived from Palaeozoic Rocks ..	

* These terms are tentative United States Soil Survey groups.

(*b*) CLASSIFICATION.

In most soil surveys and particularly those of Australian soils, there is usually difficulty in assigning some soils to established great soil groups. The present survey has proved no exception. While every effort was made to place the soils in Stephens' (1953) classification, some would not fit any of his groups nor those of other proposed classifications of Australian soils. In such cases these soils were described and their affinities with any established great soil group pointed out.

Because the soils of one group are sometimes dominant in more than one association the mapping units could not always be named simply from their dominant great soil group. This difficulty has been overcome by describing the mapping units under the general heading of their dominant constituent great soil group with some qualification indicating the reason for any subdivision into more than one mapping unit. For instance, under the general heading of lithosols two mapping units were distinguished, lithosols derived from lateritic sandstone material and those derived from Palaeozoic rocks.

The mapping units and the great soil groups, or nearest related groups of their dominant soils, are shown in Table 10.

2.—Description of the Soils.

In this section the morphological features of the various soils are discussed together with their geographical distribution. Generally discussions regarding pedogenesis have been reserved until a later Chapter (VIII.). Analytical data for each soil group are also discussed but complete analyses are given in Appendix 11. Brief reference is also made to the associated vegetation of each soil group. Soil profile descriptions are based on the terminology used in the United States Soil Survey Manual (1951).

(a) RECENT ALLUVIAL SOILS.

Group 1.—Recent Alluvial Soil Association.

Gross area 112,000 acres.

This association is found bordering Macintyre Brook, the Dumaresq River, the Macintyre River as far downstream as Goondiwindi, and parts of the Weir River. In general the soils are developed on Recent alluvial terraces, and frequently the degree of profile development is not marked. On most streams there are two terraces developed ; the lower one is narrow and subject to seasonal inundation but even the higher older terrace may be covered by extreme floods. The inner margin of the older terrace is usually marked by a low levee which slopes gradually away from the stream but where no lower terrace is developed this levee forms the actual bank of the watercourse.

Soils of the Younger Terraces and Levees—

The soils of the lower terrace and of the levee are deep with a little-differentiated profile. Textures are in the sandy loam-loam-silt loam range with less often sands or silty clays. These deep profiles have been best studied at the site of the tobacco experiment station on Macintyre Brook some ten miles south-west of Inglewood. The following pit-profiles have been made available by courtesy of the Queensland Department of Agriculture and stock :—

(i.) Profile of soil developed on lower terrace, Macintyre Brook*—

0– 6 in. Reddish-brown silt loam, moderate medium blocky, dry, slightly hard.

6–28 in. Reddish-brown silty clay loam, slightly mottled yellowish-brown, moderate coarse blocky, very moist, slightly sticky.

28–43 in. Brown silt loam, slightly mottled yellowish-brown, moderate coarse blocky, very moist, slightly sticky.

43–60 in. Brown clay loam, strong medium blocky, moist, friable.

60–120 in. Brown loam, massive, moist, friable.

(ii.) Profile of levee soil, Macintyre Brook*—

0– 8 in. Brown loam, strong coarse blocky, dry, slightly hard.

8–16 in. Brown loam, strong coarse blocky, moist, very firm.

16–28 in. Light-brown loam, mottled reddish-brown, medium coarse blocky, wet, slightly sticky.

28–54 in. Light-brown loam, slightly mottled yellowish-brown, strong coarse prismatic, wet, slightly sticky.

54–68 in. Light-brown loam, distinctly mottled yellowish-brown, weak coarse prismatic, very moist, compact, carbonate and few manganese concretions.

68–74 in. Light-brown loam, massive, dry and hard, carbonate concretions.

* Description by F. Chippendale.

Along the Macintyre River in the vicinity of Goondiwindi and along parts of the Weir River the levee soils are frequently of finer texture but again profile differentiation is only weak. These soils may be illustrated by the following profile from near the junction of the Macintyre River and Callandoon Branch :—

0– 4 in.	Light-greyish-brown silty clay, weak crumb, fairly hard, merges into
4–28 in.	Grey-brown clay, medium blocky, fairly hard, merges into
28–36 in.	Greyish-brown clay, fairly coarse blocky, hard.

Along the Weir River in the vicinity of Tarriwinnibar coarser textured soils with weak profile development occur, the coarser texture probably being a consequence of the extensive sandy areas fringing this stream in its upper reaches. This soil is illustrated by the following profile four miles south-west of Tarriwinnibar :—

0–24 in.	Light-brown fine sandy loam, very weak blocky, soft.
24–36 in.	Light-brown loam with faint orange and grey mottling, weak blocky, slightly hard.

Isolated areas of these coarser textured alluvial soils also occur elsewhere in the region. Most streams, especially where they traverse dominantly sandy surfaced regions, have small fringing alluvial developments but these are usually too small to map.

The vegetation of these soils, which are normally developed in close proximity to the streams, is usually an open fringing forest of *Eucalyptus camaldulensis*, *E. populnea* and *E. melanophloia* with occasionally *E. microtheca* and *E. tessellaris*. The grass cover consists mainly of *Bothriochloa decipiens* and *Stipa verticellata*.

Analytical Data—

Generally these soils are slightly acid to neutral for the first several feet below which they become weakly alkaline. pH values higher than 8 recorded in the deeper horizons of one of the levee soils are apparently a result of the presence of appreciable sodium on the exchange complex. In the upper levels of the profile calcium is the dominant exchangeable metal cation but with depth magnesium may become co-dominant and in some cases there may be significant amounts of exchangeable sodium. The " available " phosphate status of these soils is high, values for the surface soils ranging from 100 to 200 p.p.m. P_2O_5. Total nitrogen is usually on the low side and the soluble salt and chloride content is normally low.

Soils of the Older Terraces and Levee Slopes—

The older terrace is much more extensive and slopes very gently away from the levee often for distances ranging from one to two miles. Frequently this generally flat surface is interrupted by old drainage lines which are now non-functional except in high floods or periods of heavy rain. The soils have a more marked profile development than those of the levee or lower terrace and may be described as minimal or submature red-brown earths. The surface soils range from loams to clay loams with a heavier, compacted B horizon at depths slightly less than two feet. The colour of the A horizons is brown or greyish brown but the compacted B horizon is usually reddish brown. Isolated carbonate nodules often occur in the deeper subsoil. The following profiles are typical of these soils :—

(i.) Profile near Beebo School, north-east of Cunningham Weir, Dumaresq River*—

A_1	0–10 in.	Grey-brown loam, mottled brown, moist, granular, friable.
B_1	10–24 in.	Brown clay loam, mottled grey-brown, moist, granular, friable.

* Description by F. Chippendale.

B_{21}	24–36 in.	Brown clay, mottled reddish-brown and grey, moist, massive, firm.
B_{22}	36–48 in.	Brown clay, mottled reddish-brown and grey, dry, massive, very hard.
BC	48–67 in.	Reddish-brown clay, mottled brown, dry, massive, hard, scattered carbonate nodules.

(ii.) Profile on Macintyre Brook alluvials, 7 miles south-west of Inglewood—

A_1	0–10 in.	Light-greyish-brown silt loam, dry, weak blocky, slightly hard, merges into
A_2	10–20 in.	Light-brown clay loam, angular blocky, fairly hard, fairly sharply defined from
B_2	20–36 in.	Reddish-brown clay, dry, massive, hard and compacted.

These two profiles may be regarded as characteristic of the older terrace soils in most areas but along the Macintyre River between Yelarbon and Goondiwindi the profile may be a little different with a thin powdery surface and a lighter coloured B horizon. This is shown by the following profile near the old Goondiwindi road opposite Bengalla :—

A_1	0– 2 in.	Light-grey-brown clay loam, powdery with slight platy structure, fairly sharply defined from
B_2	2–24 in.	Light-grey silty clay, weak blocky to massive, compacted, merges into
BC	24–36 in.	Yellowish-brown light clay, massive, friable, merges into
BC	36–60 in.	Yellowish-brown light clay, massive, hard and compacted.

This soil is particularly susceptible to wind erosion in areas where excessive stocking has depleted the grass cover. Bare areas with the surface soil removed quite frequently occur on stock routes.

The vegetation of these older terrace soils is a woodland dominated by *Eucalyptus melanophloia* and *E. populnea* with occasionally *Angophora intermedia.* The grasses are mainly *Bothriochloa decipiens* and *Stipa verticellata.*

Analytical Data—

The A horizons of the submature red-brown earths are slightly acid to neutral but pH values rise to 8 or slightly higher in the B horizons and deeper subsoils. Calcium is the dominant exchangeable metal cation in the A horizon but magnesium may become co-dominant in the B horizon and deeper subsoils. Exchangeable sodium usually shows a marked increase with depth, commonly averaging 25 per cent. of the total exchangeable metal cations in the B horizons and deeper subsoils. The total soluble salt and chloride content also show a parallel rise with depth. The available phosphate status of the surface horizon is fairly good, ranging from 60 to 150 p.p.m. P_2O_5.

Minor Associated Soils—

Throughout the area dominated by these submature red-brown earths there are small occurrences of other soils normally characteristic of a particular topographic environment. In some cases they may be relict sand ridges, of small extent and only slightly elevated. These have a rather uniform sand or loamy sand profile to depths often exceeding six feet. In the depressions and old drainage lines and areas with a restricted surface drainage soils are developed with a typical solodized-solonetz morphology. Such areas are often characterised by a vegetation of sandalwood. The following profile from a flat depression area on the Macintyre River alluvials opposite Bengalla is typical :—

A_1	0– 4 in.	Light-grey-brown silty clay, compact surface, dry, slightly hard, merges into
A_2	4– 5 in.	Light-grey silty clay (bleached), porous and massive, sharply defined from
B_{21}	5–12 in.	Greyish-brown heavy clay, tough and massive, merges into
B_{22}	12–26 in.	Grey-brown heavy clay, massive to coarse blocky, firm to hard, merges into
BC	26–36 in.	Yellowish-brown medium clay, fairly friable.

Downstream from Kildonan the older terrace soils tend to be less dominated by the sub-mature red-brown earths ; in this region there is a development of light-grey clay or clay loam soils that have little profile differentiation except for a thin incipient A_1 horizon.

(*b*) GREY AND BROWN SOILS OF HEAVY TEXTURE.

The term grey and brown soils of heavy texture was first used by Prescott (1931) to describe fine-textured soils which were characterised by little tendency to clay eluviation and the presence of carbonate close to the surface and gypsum at depth. Hallsworth and Costin (1950) used the Russian term sierozem to describe similar soils and in the preliminary survey of the resources of the Namoi Region, New South Wales (1950), immediately to the south of the present area, the description and map of the soils (compiled by F. R. Gibbons and E. G. Hallsworth) uses the term sierozem-like to describe soils which are identical with those which are described in the present report as grey or brown soils of heavy texture.

Stephens (1953) separated Prescott's original unit into two groups, the grey soils of heavy texture and the brown soils of heavy texture. He stated that they are essentially weakly hydromorphic soils and that the grey soils which generally occur on the lower portions of alluvial plains of the major inland watercourses were subject to occasional flooding which produced the required hydromorphic effects without sufficient leaching to remove carbonate and gypsum. The brown soils were stated to usually occupy slightly higher or better drained sites which modified the hydrological process so that a brown colour is developed. These ideas have been readily substantiated in most instances in the present study. However, it was not possible in some cases to map separately the grey soils and the brown soils as where they are derived from marine Cretaceous sediments there is normally a catenary sequence while in areas where linear gilgai have developed a soil complex is formed. In spite of this, two naturally distinct associations can be described and mapped, the grey soils of heavy texture derived from alluvium and the grey and brown soils formed on marine Cretaceous sediments.

Group 2.—Grey Soil of Heavy Texture Association.

Gross area 373,000 acres.

This soil association has its greatest development in the flat lowlying areas subject to fairly frequent flooding between the Macintyre and Weir Rivers west of Goondiwindi. Elsewhere in the region only small localised developments occur in areas with restricted surface drainage resulting in ponding following periods of heavy rain. The general terrain occupied by these soils is very flat but there may be a very slight gilgai microrelief in some areas. In dry periods the soils crack extensively.

These grey soils are deep with a profile that shows little differentiation into horizons. The colour is normally grey, dark grey, or grey-brown at least to 40 inches and there is no apparent eluviation of clay, the texture being uniformly heavy to medium clay throughout the profile. The surface soil has a fairly coarse granular self-mulching structure, then becoming very coarse blocky to massive. Occasionally there is a slight dull mottling developed below 24 inches. Carbonate is usually absent in the upper 6 inches of the profile but below this is normally present throughout in moderate to high amounts, often in the form of nodules. Gypsum has only occasionally been recorded in small amounts and then at depths in the vicinity of 6 feet. The following profiles illustrate the essential characteristics of these grey soils of heavy texture :—

(i.) Profile ¾ mile south of Toobeah—

0– 1 in. Grey heavy clay, strong coarse granular self-mulching, fairly hard.

1– 40 in. Grey heavy clay, very coarse angular blocky becoming massive, hard when dry, very plastic when moist, slight carbonate throughout.

40– 66 in. Greyish-brown to brown medium clay, massive, hard when dry, very plastic when moist, slight to moderate carbonate.

66– 84 in. Light-brown tending yellowish-brown medium to light clay, friable when moist, moderate carbonate nodules.

84–120 in. Yellowish-brown light clay, some small yellowish fleckings, friable when moist, moderate to slight carbonate nodules.

120–192 in. Yellowish-brown light clay tending light yellowish-brown fine sandy light clay, very friable when moist, some black manganiferous stains and very dull ill-defined greyish and yellowish mottling.

(ii.) Profile 2 miles south of Commoron Creek, Goondiwindi-Goodar road.

0– 1 in. Grey heavy clay, strong coarse granular self-mulching, fairly hard.

1–36 in. Dark-grey heavy clay, very coarse blocky tending massive, hard when dry, very plastic when wet.

36–50 in. Grey-brown medium clay, massive, plastic, numerous carbonate nodules up to ¼ in. diameter.

50–70 in. Greyish-brown clay becoming lighter in colour with depth, firm to friable, carbonate nodules still fairly frequent.

In these above two representative profiles all horizon boundaries are very diffuse, colour and structural changes are very gradual, often extending over a depth of 12 inches. Where there is slight gilgai microrelief the puff and depression profiles are similar, usually with the surface soil of the puff somewhat lighter in colour than that of the depression and sometimes with the carbonate nearer the surface.

Analytical Data—

Mechanical analyses show a high proportion of clay (63–66 per cent.) and a very low proportion of sand (6–10 per cent.) which appears fairly uniform throughout the upper levels of the profile. The deep parent material alluvium in the Toobeah profile, although a light clay by field texture, contains only 28 per cent. clay with a high proportion of fine sand (56 per cent.).

The soils sampled show some variation in reaction but are normally slightly alkaline to neutral throughout the profile. One sample showed a pH value of 7·8 in the upper 12 inches then falling to values near neutral while other samples were in the range 7 to 7·4 throughout the profile. The clays of the surface 6 inches are almost fully base saturated, with calcium as the dominant exchangeable cation and magnesium also prominent. Exchangeable sodium reaches significant levels in some profiles, ranging up to 10 per cent. of the total exchangeable metal cations. The total exchange capacity is of the order of 75 m. equiv./100 g. clay so that the clay minerals are probably dominantly montmorillonitic.

The chloride content is high below 12 inches, ranging from 0·16 to over 0·5 per cent. NaCl, total soluble salts are also correspondingly high below 12 inches. Organic carbon is rather low in the surface horizons (0·7—0·75 per cent.) for such fairly dark fine textured soils. Total nitrogen is also low in the surface soils and C/N ratios range from 10 to 15. Available phosphate ranges from 36 to 66 p.p.m. P_2O_5 in the upper 12 inches of the profile. Physical studies indicate that these soils have a very high wilting point (20–25 per cent.) with an available moisture range of some 10 to 15 per cent.

Vegetation—

The vegetation of these grey soils of heavy texture is typically an open grassland or parkland with a well developed diverse gramineous flora, the major species being *Astrebla lappacea, Dichanthium sericeum, Iseilema membranaceum* and *Panicum decompositum.* Tree species are usually *Eucalyptus microtheca, Heterodendron oleifolium* and *Acacia pendula* with occasionally *Casuarina lepidophloia.*

Minor Associated Soils—

There is a constant and close relationship throughout the grey soil of heavy texture areas between these soils and weakly solodized-solonetz soils which are invariably developed in close association with both functional and non-functional drainage lines. The more extensive of these latter soils have been mapped separately and their characteristics and relationships are discussed later (Group 7). However, numerous smaller occurrences, especially along lesser drainage lines, could not be separately mapped so that they are to be regarded as more or less constant minor members of the heavy grey soil association. The characteristic distribution pattern of these heavy grey clays and their weakly solodized-solonetz associates is clearly shown on Plate 21, an aerial photograph of part of this soil region.

Similarly throughout the grey soil areas there are fairly common relict aeolian sand ridges, the more extensive of which have been mapped and described separately (Group 10), but once again smaller occurrences have to be regarded as forming a very minor component of this grey soil association. Finally it may be mentioned that in this association there are no typical brown soils of heavy texture.

Group 3.—Grey and Brown Soil of Heavy Texture Association.

Gross area 109,000 acres.

The soils of this association are rather restricted in their distribution, being confined to the areas of marine Cretaceous sediments that occur in the region. The chief occurrence is in the vicinity of Coomrith with much smaller developments south-west of Glenmorgan and around Tarriwinnibar and Lundavra.

These soils are developed on an entirely different topography to that of the preceding association of heavy grey soils. In general they are formed on an undulating landscape which possesses much more relief than the typical western Queensland occurrences. This has led to the development of distinct catenary sequences which have made it impossible to separate the grey from the brown soils at this scale of mapping. The pattern is further complicated by the fact that on some of the slopes there is a strong development of linear gilgai (wavy gilgai of Hallsworth

Plate 15.

Open mitchell grass grasslands 10 miles north-west of Goondiwindi with some clumps of coolibah in the background. *The soils are self-mulching dark-grey heavy clays.* (Group 2).

Plate 16.

Undulating landscape formed on marine Cretaceous sediments near Coomrith. The soils are brown calcareous clays that darken and become greyer towards the bottom of the slopes.

et al 1955), giving a soil complex. In general brownish—often reddish-brown, soils are developed on the crests of the ridges and the upper slopes. These darken in colour and become deeper down the slope until on the lower slopes and flat valley floors there are dark-grey soils which may have a very slight gilgai microrelief and display deep cracking when dry. Linear gilgai formation appears related to the degree of slope, on steeper slopes and areas of very gentle gradient it is absent.

The soils developed on the crests and upper slopes of the ridges are frequently not typical brown soils of heavy texture. They are often shallow and have a reddish-brown colour. Gypsum does not occur but free carbonate is found. They are usually finer structured than the typical grey soils of heavy texture. A characteristic profile is as follows :—

Profile 5 miles north of Coomrith on the Glenmorgan road.

0 –5 in. Dark-reddish-brown medium clay, medium angular blocky, hard, merges into

5–12 in. Reddish-brown heavy clay, coarse blocky, firm, trace of carbonate, merges into

12–18 in. Yellowish-grey-brown clay with decomposing calcareous sandstone and small pockets of red-brown clay.

18 in. + Decomposed calcareous sandstone.

Further down the slopes these soils lose their reddish colour and become deeper more typical brown soils of heavy texture with free carbonate but again apparently without gypsum. They in turn darken further down the slope until at the foot and covering the intervening valley floors there are deep dark grey soils which in the upper parts of their profiles closely resemble the grey soils of the previous association (Group 2). A typical profile of these grey soils at the foot of the slope from the top of which the above brown soil profile was taken is as follows :—

0– 1 in. Grey clay, strong coarse granular, self-mulching, firm, merges into

1–33 in. Dark-grey heavy clay, coarse blocky to massive, hard when dry, plastic when moist, moderate carbonate nodules, merges into

33–48 in. Yellowish-grey-brown medium clay, massive, firm, moderate soft carbonate

48–60 in. Light-yellowish-brown medium clay with some grey and yellow mottling, friable, slight carbonate.

The linear gilgai formation on some slopes forms a rather striking soil complex. Although the gilgai vertical interval is small (never greater than 6 inches, usually less) and the wave length some 25 feet the soils of the puff and depression form a sharp contrast. The following profiles from near the Myallstone race track south of Meandarra illustrate the diverse soils of the puff and depressions.

Puff Profile—

0– 3 in. Reddish-brown to light-reddish-brown light clay, slightly platy weak self-mulching surface then medium blocky, friable, moderate carbonate, merges into

3–36 in. Light-brown medium clay, coarse blocky to massive, firm to hard, abundant soft carbonate to 24 in. then moderate, merges into

36–54 in. Bright-brown medium clay, massive, fairly hard, moderate soft carbonate with some nodules.

54 in. + Decomposing calcareous sandstone.

Depression Profile—

0– 4 in.	Greyish-brown medium clay, medium angular blocky, firm to hard, merges into
4–20 in.	Dark-grey-brown medium to heavy clay, coarse blocky, hard, merges into
20–30 in.	Grey-brown heavy clay, massive, hard, trace of carbonate, merges into
30–42 in.	Bright-brown medium clay, massive, hard, moderate to abundant carbonate.
42 in. +	Decomposing calcareous sandstone.

These profile features more or less conform to the theory of gilgai formation (Hallsworth *et al* 1955) that the puffs represent the subsoil horizons of the depressions that have been forced to the surface. However, the gilgai phenomena appear remarkably well developed considering the rather shallow nature of the soil. The lighter coloured surface horizon of the depression which may contain traces of free carbonate is obviously due to material eroded from the surface of the puff. A further field distinction between puff and depression is afforded by the fact that they support different grass species. On the puffs *Aristida latifolia* is dominant while *Dichanthium sericeum* is characteristic of the depressions.

Analytical Data—

The soils are normally moderately alkaline throughout although the upper horizons of the linear gilgai depressions may be neutral to slightly acid. Calcium is the dominant exchangeable metal cation in every horizon with magnesium subdominant. Exchangeable sodium is usually present in significant amounts in all but the surface horizons of all profiles. Chloride content is much lower than in the grey soils of Group 2, especially in the slope soils. This is apparently related to their better drainage as deep samples from less well drained sites on the valley floor contain up to 0·26 per cent. chloride as NaCl. Total soluble salt figures are correspondingly lower than Group 2 soils except for deeper samples on less well-drained sites. Organic carbon contents in the surface soils, even those of the puffs, are often twice those of the grey soils of Group 2. Total nitrogen is also higher than for Group 2 soils. Available phosphate is fairly low in the slope soils (40 p.p.m. P_2O_5 or less) but is high in the grey soils of the valley floors (100–120 p.p.m.).

Vegetation—

The vegetation of the grey and brown soil association is an open parkland which varies in composition according to the catenary soil sequence. On the ridge crests and upper slopes there is normally a *Eucalyptus populnea–E. melanophloia* community, further down the slopes *E. microtheca* and *Acacia pendula* become more prominent and usually dominate the vegetation of the flatter valley floors. A dense ground cover of *Dichanthium sericeum* is usually present.

Minor Associated Soils—

The more important stream lines draining these grey and brown soils originate in higher areas where lateritic residuals are common and such streams usually have small alluvial terraces and minor flood plains on which red-brown earths are developed. Also on the lower slopes of some ridges there are small areas of weakly solodized-solonetz soils, usually characterised by a vegetation of sandalwood.

(c) SOILS CLOSELY RELATED TO GREY AND BROWN SOILS OF HEAVY TEXTURE.

The most extensive broad soil group occurring in the region consists of grey and brown clays which usually possess a very strong gilgai microrelief and support a dense forest vegetation largely dominated by brigalow. This soil group is part of a much larger development which extends intermittently northwards in Queensland at least as far as the 20th parallel of latitude and lies generally within the 20-inch and 30-inch rainfall isohyets. To the south there is a similar continuation into New South Wales. The soils of this great belt exhibit considerable variation and often they do not fall readily into any of the established great soil groups. Thus some of these clay soils have been variously described as modified black earths (Prescott and Skewes 1941), grey and brown calcareous soils (Skerman 1951) in Queensland while in New South Wales in the survey of the Namoi Region (1950) similar soils were described as chernozem-like. Quite commonly also these soils have been merely referred to as " brigalow soils " in many unpublished Queensland soil reports and in earlier work (1954) the writer also used this expedient. However, this broad grouping frequently included a somewhat diverse range of soils, in particular those with a distinct clay loam A horizon and supporting a belah dominant vegetation. The present study has shown these to be quite distinct from the more typical clay soils supporting a generally brigalow dominant vegetation and they have been separated accordingly (Group 6).

Closer studies of these strongly gilgaied clay soils by the writer and the C.S.I.R.O. Division of Soils, have revealed certain additional interesting features. The most striking of these is the fact that throughout this southern border region the subsoils of these clays are very strongly to extremely acid (pH 4.5–4.0) while in some instances the soils may be acid throughout both puff and depression profiles, although only slightly so at the surface. These acid profiles have been noted before but they were thought to be atypical minor variations. Thus Beadle (1948) at Carinda in north-western New South Wales listed a clay soil supporting brigalow as having a slightly acid surface and a very strongly acid subsoil while Skerman (1953) mentioned that in rare instances a brigalow soil may be acid throughout the profile. Hallsworth *et al* (1955) in their study of the gilgai soils of New South Wales refer to the acid gilgai soils of the Pilliga region but they do not quote any reaction values. Additional studies in other parts of Queensland by the author and by the C.S.I.R.O. Division of Soils have indicated that clay soils supporting brigalow and possessing a strong gilgai microrelief and with strongly acid subsoils are widespread. This has been recently briefly discussed in a joint publication (Hubble and Isbell 1958.)

Other important features of these clay soils apart from their acid subsoils and strong gilgai microrelief are the presence of free carbonate in the upper levels of those profiles which are alkaline and the variable presence of gypsum crystals, often at relatively shallow depths. Chemical studies indicate that these soils have been subjected to halomorphic influences as soluble salts are normally high throughout the profile and the exchange complex may contain considerable amounts of exchangeable sodium.

It is thus somewhat difficult to classify these soils in terms of any of the established great soil groups. They are most closely related to the grey and brown soils of heavy texture but their frequent acid nature makes them a rather unique group at present.

Two fairly distinct associations can be readily recognised but their mapping is a more difficult problem. The most common and more extensive association consists of grey or grey-brown clays which may be acid throughout the profile and invariably possess a strongly developed gilgai microrelief. The other association appears to be of much more limited extent and is characterised by brown or slightly reddish brown clays with a weaker gilgai development and so far as is known from limited sampling, does not appear to contain soils which are acid throughout the profile although the subsoils are still strongly acid.

Group 4.—Grey Clay Association.

Gross area 1,586,000 acres.

These soils have a wide distribution extending generally from the limits of the sandy Blythesdale Group in the east to the extreme west of the area surveyed which appears to be approaching the westward limit of the more extensive developments in this region at least. Other smaller developments occur within areas of dominantly coarser-textured soils which appear to have been derived from the sediments of the Blythesdale Group. Over the extensive areas in which they occur these grey clays are normally situated on an almost flat topography which is disturbed by only minor undulations in the form of broad very gently sloping ridges and valleys.

Plate 17.

Cleared brigalow country near Cobba-da-mana east of Inglewood showing the typical strong gilgai microrelief with the depressions averaging 3 to 4 feet in depth. The soils are greyish-brown clays which are acid throughout the profile although only slightly so at the surface.

Plate 18.

Cultivated brigalow country between Yelarbon and Goondiwindi showing how even the shallower depressions here still remain after several ploughings. These soils are alkaline in their upper levels.

Plate 19.

Aerial photo (approx. scale 15 chains = 1 inch) of cleared brigalow gilgai country north-west of Commoron Creek junction. Photo taken *during the 1955 flood*, the darker areas are the water-filled depressions. Note the sharp boundary between the gilgai formation and the heavy grey clays and weakly solodized solonetz soils adjacent to the watercourse.

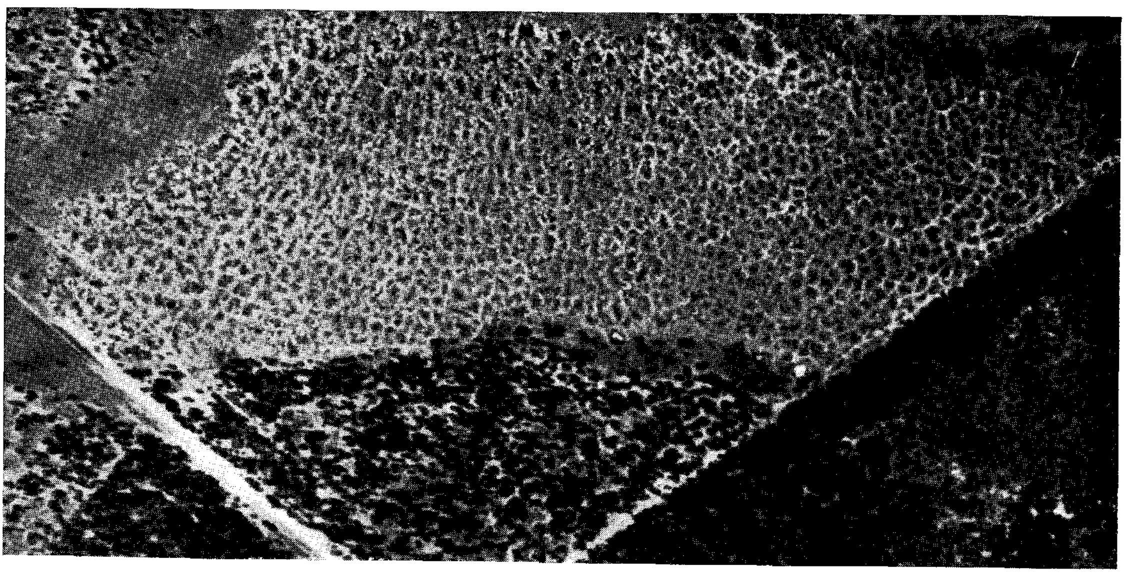

Plate 20.

Aerial photo (approx. scale 15 chains = 1 inch) of cleared brigalow gilgai country 1¼ miles south-east of Wyaga station. The darker areas are the depressions and here they are subcircular to elliptical in contrast to the elongate forms in Plate 19.

One of the most striking features of these soils is the very strong degree of gilgai development that they usually exhibit. The vertical interval between the puff and depression may be as great as six feet although more commonly it ranges from two to four feet. According to the classification of Hallsworth *et al* (1955) most of the gilgai appears to belong to the normal or network types with the puffs and depressions usually equally well developed but often there is a tendency for the puffs to be continuous and somewhat elongated with the depressions subcircular to elliptical (Plates 19, 20). (The term shelf as used by Hallsworth *et al* is not considered to be appropriate for the lower depressed areas of often considerable magnitude adjacent to the puffs, the term depression is considered to represent a more accurate description of the conditions obtaining.)

Thus the soils have to be considered in terms of puff and depression profiles as there are normally appreciable differences in the upper parts of the two profiles although horizon differentiation is only very weakly expressed. The surface of the puff is normally a grey or greyish-brown clay which may be slightly platy to moderately granular self-mulching. Free carbonate may occasionally be present on the surface of the puffs and then the clay tends to be more friable. The surface soil of the neutral to acid surfaced puffs often has a very light-greyish-brown colour that is to be contrasted to the darker-greyish-brown or grey colour of the alkaline surface soils. This surface layer quickly passes into a greyish-brown or grey heavy clay which is hard and tough when dry and plastic when moist with a coarse blocky structure which persists usually at least to a depth of 36 inches with the structure becoming more massive with depth. Free carbonate may occur in the upper levels of some profiles while gypsum crystals may be present below 12 inches and extend to 50 inches, often occurring with the carbonate but normally below it. The deeper subsoils continue a greyish-brown clay to 6 feet and normally much deeper. These subsoils often exhibit what might be described as a lenticular structure, the clay tending to break into lens-like units which have curved and occasionally slickensided surfaces. The clay aggregates usually possess what appear to be fairly well developed clay skin surfaces. In the lower levels (around 6 feet) of several puff profiles examined there were isolated small fragments of white kaolinitic material while much more commonly there are small black manganiferous stains and fleckings. Also with depth a fairly pronounced dull red and grey mottling may be encountered. When dry the soils of the puffs may display fairly strong deep cracking.

The surface soil of the depressions is normally a darker-grey or grey-brown clay with a coarser granular structure and commonly contains a certain amount of organic matter, ashes, &c., which has been washed in from the surrounding higher puffs. Following heavy rains the deeper depressions may retain water for considerable periods. In the upper levels of some depression profiles there may be a strong development of well rounded black manganiferous concretions ranging up to an inch in diameter. The surface of the depressions also usually displays strong deep cracking when dry. Below the surface influence of washed-in material the grey-brown clays become a little less dark and have a coarse blocky structure which becomes massive with depth. Free carbonate may occur throughout the profile and usually persists to greater depths than in the puff profiles. The deeper subsoils are similar to those of the puff and occasionally there is a dull orange mottling. A feature of the lower levels of both puff and depression profiles is the frequent presence of small pockets of sandy material, this probably has resulted from sandy material falling down deep cracks which have been observed to extend at least 36 inches.

The following profiles illustrate the chief features of these puff and depression soils :—

(i.) Profile 6 miles north-west of Yelarbon on the Cunningham Highway—

Puff Profile—becomes strongly acid below 36 inches.

0– $\frac{1}{2}$ in. Light-greyish-brown medium clay, medium granular, slightly self-mulching, fairly friable with some free carbonate, merges into

½–14 in. Light-greyish-brown heavy clay, medium blocky structure, hard when dry, plastic when moist, moderate carbonate, merges into

14–36 in. Brownish-grey heavy clay, blocky to massive, hard, slight carbonate, merges into

36–60 in. Light-greyish-brown heavy clay, firm to slightly plastic, trace of fine grit, moderate clay skin development and lenticular structural units.

Depression Profile—approximately 2 feet lower than puff, 20 feet distant. Alkaline throughout.

0–24 in. Dark-grey-brown medium clay with much washed-in organic matter, thin granular surface, then hard and coarse blocky, merges into

24–36 in. Grey-brown heavy clay, coarse blocky to massive, hard, trace of carbonate, merges into

36–60 in. Greyish-brown heavy clay, more friable, slight to moderate carbonate, weak clay skin development, merges into

60–72 in. Light-greyish-brown heavy clay, firm to slightly plastic, trace of carbonate, weak clay skin development.

(ii.) Profile 3 miles south of Tara—

Puff Profile—Neutral surface becoming strongly acid at 12 inches (pH 4·5) and continuing.

0– ½ in. Light-greyish-brown medium clay, slight platy structure, self-mulching, friable, merges into

½–10 in. Greyish-brown to brown heavy clay, weak medium blocky, fairly friable, merges into

10–24 in. Greyish-brown heavy clay, coarse blocky to massive, hard, merges into

24–60 in. Greyish-brown heavy clay, slightly sandy, firm to hard with lenticular structure and small black fleckings and stains. Moderate clay skin development.

Depression profile—approximately 2 feet lower than puff, 30 feet distant. Profile acid below 24 inches and very strongly so at depth.

0–24 in.—Grey heavy clay with plant residues washed in from puff, sticky to plastic, trace of carbonate, merges into

24–36 in. Grey-brown heavy clay, plastic, merges into

36–60 in. Grey-brown to greyish-brown heavy clay, firm to friable with a lenticular-like structure and some occasional dull orange mottling, moderate clay skin development.

(iii.) Profile 3 miles south-east of Glenmorgan along Meandarra Road—

Puff Profile—acid throughout, pH 6·4 at surface, 4·1 at 6 feet.

0– 6 in. Greyish-brown heavy clay, slightly granular surface then hard and angular blocky, merges into

6–24 in. Brown heavy clay, hard and coarse blocky tending firm and massive, merges into

24–72 in. Brown heavy clay, becoming greyish-brown with depth, massive tending lenticular, occasional small rusty inclusions and some greyish sandy patches, moderate clay skin development.

Depression Profile—approximately 3 feet lower than puff, 15 feet distant. Profile acid throughout, pH 6·0 at surface, 4·4 at 6 feet.

0– 6 in. Grey-brown heavy clay with some washed-in organic matter, fairly extensively cracked, merges into

6–12 in. Grey heavy clay, coarse blocky to massive, hard, some lighter coloured slightly sandy patches of material from surface fallen down cracks, merges into

12–72 in. Greyish-brown heavy clay, massive tending lenticular, firm to hard. Small rusty flecks in lower levels and some small greyish sandy patches, moderate clay skin development.

In those puff profiles in which crystalline gypsum has been found it occurred at depths ranging from 10 to 40 inches, in most cases occurring below the level of free carbonate but frequently partly overlapping it. The gypsum often occurred at profile levels which were strongly acid. Evidence from excavated earth tanks and deep borings has shown that the depth of clay material which constitutes these soils ranges from 6 feet to 25 feet and possibly greater. While there is often an increase of a dull red and grey mottling, at greater or lesser depths there normally appears to be a fairly sharp break to an old buried horizon which in most cases consists of the strongly mottled zone of the old laterite profile. Above this horizon the uniformity of the clay material is quite striking. However this question is further discussed in the later section on pedogenesis.

Analytical Data—

Mechanical analyses show that both puff and depression profiles consist of medium to light clays throughout (40–50 per cent. clay) but with little or no evidence of any increase with depth. This is contrary to the evidence of Hallsworth *et al* (1955) who stated that for New South Wales gilgai soils the depression profiles always showed a marked increase in clay content with depth. Rather in these soils there is a slight tendency to a decrease of clay content in the depression profiles. The silt content is fairly low and the sand moderately high (30–40 per cent.) throughout. The field texture of these soils would normally suggest a higher clay content than that revealed by the analyses.

The reaction values of these soils are extremely interesting. As stated earlier they may range from alkaline throughout (rarely) through alkaline surfaces with acid subsoils (most common) to acid throughout (fairly common). Soils which are alkaline throughout to a depth of 6 feet have been found in both puff and depression profiles but these instances do not appear to be very common in this region. Most commonly both puff and depression profiles are alkaline in their upper levels but rapidly become acid at often shallow depths. This is illustrated by the Tara puff profile described above which was sampled every 2 inches to a depth of 40 inches. Fig. 5 shows graphically the change in pH with depth for this Tara puff profile and also the reaction change for a similar gilgaied clay soil from near Inglewood

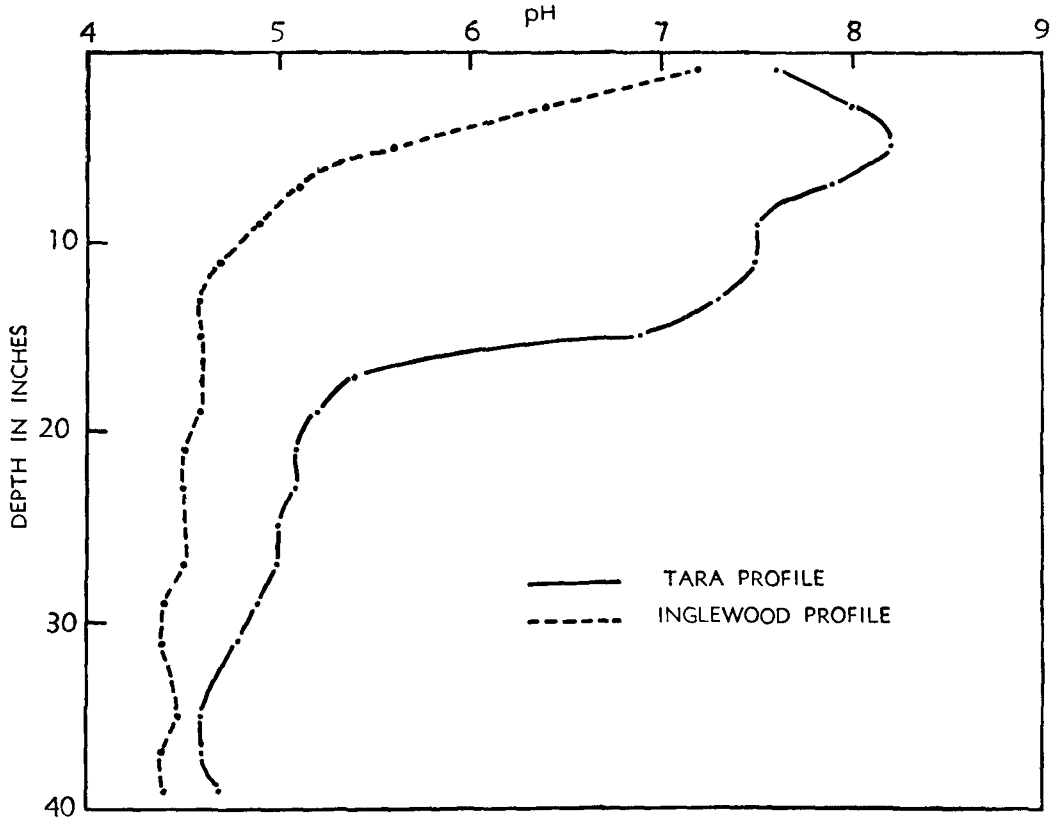

Fig. 5.—Graph showing nature of pH change with depth for two puff profiles.

It is thus evident that the rapid change from alkaline to strongly acid conditions takes place over a very short depth range. Profiles which are acid throughout may be as low as pH 6 at the surface and show a rapid increase in acidity with depth, falling to pH 4·5 at 12 inches. At 6 feet the highest acidity encountered in these soils was pH 4·0.

A study of the exchangeable cations also reveals unusual features. The clays of alkaline or neutral horizons are 80 to 90 per cent. saturated but the exchangeable hydrogen of horizons with a pH range of 4·5 to 4·0 is still only 30 per cent. of the total exchangeable cations and seems insufficient to explain the low pH values. Johnstone (1953) in the Deniboota region of south-western New South Wales also has recorded similar phenomena and he remarked on the unusual and as yet unexplained combination of high acidity with values of exchangeable hydrogen comparable with those mentioned above.

Where the soils are alkaline and contain free carbonate calcium is the dominant exchangeable metal cation but exchangeable magnesium is also fairly high. With acid conditions magnesium becomes dominant but only up to 45 per cent. of the total exchangeable metal ions, calcium is normally still subdominant, even in horizons with pH 4·5 constituting up to 27 per cent. of the total exchangeable metal ions. However sodium may also be prominent and range up to 30 per cent. of the total exchangeable metal ions. There is normally a tendency for sodium to increase with depth but this trend is not well defined and both puff and depression profiles may show a sharp drop below 5 feet. Exchangeable potassium is present in normal amounts throughout the profile. The total exchange capacities of the soils range from 60 to 70 m.equiv./100 g. 2μ clay and are not appreciably lower, if at all, in the strongly acid horizons. This would suggest then that the clays must contain a considerable proportion of montmorillonitic minerals throughout. This question is again referred to in the section on pedogenesis (VIII.).

The chloride and total soluble salt contents of these soils are high except in the surface 12 inches. Below this chlorides normally exceed 0·2 per cent. NaCl and may rise to 0·5 per cent. in the deeper subsoils. Chloride, expressed as NaCl, accounts for approximately half of the total water soluble salt content. Total nitrogen in the upper 12 inches of the puff usually ranges from 0·08 to 0·1 per cent. while the depressions are normally somewhat higher. Organic carbon in the upper levels of the puff profiles ranges from 0·7 to 1·0 per cent. with the depression values again slightly higher, mainly as a result of washed-in organic matter. C/N ratios range from 8 to 10 for the puffs with the depressions slightly higher. Available phosphate figures are low to very low except in certain depression profiles containing much organic matter. (See Table 11.) Values are often less than 25 p.p.m. P_2O_5 for all sections of the profile. Total phosphate determined on one profile was also very low with values averaging 0·003 per cent. P_2O_5 for the upper 12 inches of both puff and depression profiles and less for lower horizons. The corresponding available P_2O_5 figures were 20–25 p.p.m. The Tara puff profile was analysed for available P_2O_5 every two inches to a depth of one foot over a pH range of 7·2 at the surface to 4·7 at 12 inches but showed no change in available P_2O_5 over this pH range, values remaining constant at 26–28 p.p.m.

Limited physical studies indicate that these soils have fairly high wilting points and field capacities although not as high as the grey soils of heavy texture of Group 2.

Vegetation—

The ecology of the brigalow areas has been fairly fully discussed in the section on the vegetation (V.). It is again reiterated here that except for relatively small areas, belah always constitutes a considerable proportion of the vegetation and there is every gradation between pure brigalow communities and pure belah communities with a related gradation of soil type and degree of gilgai development. Limited sampling has also suggested the possibility of a relationship between clays which are acid throughout and the presence of almost pure stands of brigalow but studies have not been extensive enough to definitely establish this fact. It would appear though that the areas of almost pure brigalow of somewhat stunted aspect in the Glenmorgan–Meandarra region are developed on clays that are acid throughout the profile.

Minor Associated Soils—

Due to the frequent difficulty of distinguishing the belah-dominant areas on aerial photographs there are present in this mapped association some smaller areas at least of the clay loam surfaced soils of Group 6. Similarly there are also included some areas of the soils of the next association (Group 5), the brown clays supporting brigalow. Also along minor drainage lines there may be small areas of the weakly solodized-solonetz soils of Group 7. Throughout the association there are fairly frequent small sandy soil occurrences, the larger of which have been mapped separately as Groups 10 and 11, but developments too small to map are thus included in this association.

Group 5.—Brown Clay Association.

Gross area 226,000 acres.

This association occupies much less extensive areas than the previous one and is more or less confined to the western part of the region between the Moonie and Weir Rivers where it is commonly found in close association with lateritic red earths and the red-brown earths. The soils although typically brown may often have a reddish tint, probably often due to contamination from adjoining red soil areas. The degree of gilgai development of these brown clays is usually much less than in the preceding grey soil group, and frequently may be absent. There is also little difference in puff and depression profiles although the surface of the puffs is usually lighter in colour and better structured than that of the depression. There is, however, every gradation between these brown clays and the typical grey to greyish-brown clays with very strong gilgai of the previous association and they may also merge into the clay loam-surfaced soils of Group 6.

The surface of these brown clays may occasionally be covered by a thin discontinuous veneer of small ironstone nodules, most of which appear to have been washed down from neighbouring higher lateritic red earth areas. Occasionally these nodules extend in to the upper levels of the profile. The surface soils are light clay in texture and usually granular self-mulching. Horizon differentiation is not marked, the surface layer grades quickly into a brown clay of medium to coarse blocky or massive structure and this continues to around 24 inches when the clay may become reddish-brown in colour. The clays are hard when dry, plastic when moist. Below 50 inches the clay may become red-brown with fairly strong grey mottling becoming increasingly prominent. The clay aggregates again have well developed clay skin surfaces and occasional slickensided shear planes may occur. In one profile a fairly sharp break to the underlying mottled zone of the laterite was encountered at fairly shallow depths (8 ft. 6 in.). No profiles have been encountered which are acid throughout but the deep subsoils are again strongly acid. Free carbonate is apparently always present in the upper levels of the profile, often in high amounts. The following profiles illustrate the features of these soils, the two sites sampled and described below were in areas where there was virtually no gilgai development.

(i.) Profile approximately 7 miles south of Burloo Station, Bungunya–Springmount road. Slight slope.

0– 4 in.	Light-brown light clay, granular surface then medium blocky, fairly hard, merges into
4–12 in.	Brown medium clay, coarse blocky, hard, merges into
12–26 in.	Brown heavy clay, coarse blocky to massive, fairly hard but with abundant soft carbonate, merges into
26–36 in.	Reddish-brown heavy clay, massive with slight carbonate.

(ii.) Profile 2·3 miles north of Moonie River, Westmar–Meandarra road.

0– 10 in.	Bright-brown medium clay, slightly granular surface then medium blocky and fairly hard, trace of carbonate and isolated ferruginous nodules which may also occur on the surface. Merges into
10– 26 in.	Brown heavy clay, coarse blocky, fairly hard, abundant soft carbonate, merges into
26– 50 in.	Reddish-brown heavy clay, massive to lenticular, more friable, trace of carbonate, merges into .
50– 70 in.	Red-brown heavy clay with fairly strong grey mottling, lenticular structural units with clay skin surfaces and occasional shear faces. Merges into
70–102 in.	Dull-grey medium clay with dull red mottling which becomes a stronger colour with depth. Overall colour cast is a dull brownish to reddish grey. Clay skin development moderate with some marked slickensided shear planes. Material is plastic when moist. Fairly distinct break to
102–144 in.+	Bright-red and dull to light-grey mottled heavy clay with the red ferruginous material more crumbly than the grey. Overall colour cast is light red to greyish red. Clay skin development still present, also occasional shear faces. The ferruginous material often has a dark or blackish shiny surface. Material is very hard but brittle when dry, plastic when moist. This material is evidently the mottled zone of the old laterite profile.

Analytical Data—

The Moonie River soil described above contains 40 per cent. clay in the upper alkaline levels of the profile and this increases to 58 per cent. in the 7–8 ft. zone. However there is then a very slight decrease to 57 per cent. in the underlying mottled zone material.

The upper levels of these soils are normally neutral to moderately alkaline but become extremely acid at depth, values of pH 3·8 being recorded for the 6–7 ft. zone of the Moonie River profile. The underlying strongly mottled material below 8 ft. 6 in. in this profile has a pH of 3·6. Calcium is the dominant exchangeable metal cation in the upper sections of the profile but sodium may range up to 10 per cent. of the total metal ions. Exchangeable magnesium rises with depth and is dominant in the deeper subsoils. It is unusual to find that the indurated strongly red and grey mottled clay below 102 inches that apparently represents the mottled zone of a truncated laterite profile (pH 3·6) still has a relatively high total content of exchangeable metal ions (20 m. equiv. per cent.), magnesium being dominant but with exchangeable calcium still prominent. It is also unusual to note that this extremely acid material is only moderately unsaturated (47 per cent. saturation). There is thus little contrast between this material and the overlying less strongly mottled acid clay that forms the lower part of the present soil profile. Both these clay materials therefore have total exchange capacities of the order of 70 m. equiv./100 gm. 2μ clay and thus must be dominantly montmorillonitic.

Total soluble salts and chloride are again high below 12 inches, chloride averages about 0·2 per cent. NaCl in the upper sections of the profile and increases with depth, reaching 0·3 per cent. NaCl in the deep strongly mottled clay horizon. The available phosphate status of these soils is again low in the upper levels of the profile and extremely low at depth.

Vegetation—

These brown clays carry a mixed stand of brigalow and belah with either species assuming dominance in various areas. *Geijera parviflora* and *Eremophila mitchellii* are commonly associated. As noted elsewhere with the tendency of belah to dominate the community there is a lessening of any gilgai structure present.

Minor Associated Soils—

Due to difficulty in aerial photograph interpretation and traverse limitations imposed by the nature of the vegetation this association as mapped contains some areas of the strongly gilgaied grey clays of Group 4 and the clay loam surfaced soils of Group 6. In addition there may be limited areas of red-brown earths and lateritic red earths too small to map separately. Where drainage lines occur in this association they are likely to possess a narrow levee-like fringe of red-brown earths.

(*d*) WEAKLY SOLONISED SOILS.

There exist throughout the region large areas of fine textured soils that constitute a fairly distinct unit but which do not fall readily into any of the established great soil groups. These soils have affinities with the solodized-solonetz, the red-brown earths and the grey and brown soils of heavy texture. A degree of solonisation is common to all of these soils and it would appear that this factor, together with partial solodization, has been responsible for modifying soils that could otherwise have been classed as grey and brown soils of heavy texture or red-brown earths. In some cases the degree of solonisation and solodization is such that the soils could be readily classed as solodized-solonetz.

Similar soils to these appear to be common in many regions of Australia where solonisation has affected fine textured parent materials. Thus these soils of this region have much in common with the Oaky-Dowie Association of the Burdekin River floodplain in North Queensland (Hubble and Thompson 1953) and with some of the soils of the Riverine Plain of South-eastern Australia, especially some of those described as marginal red-brown earths and marginal grey and brown soils of heavy texture.

The soils of this broad group are nearly all characterised by a fairly thin clay loam A horizon overlying a fairly tough clay B horizon. A thin bleached A_2 horizon may be developed but columnar structure is seldom present in the B horizon. Salt accumulation is present in the B and lower horizons. From a slightly acid to neutral A horizon the pH normally rises to moderately alkaline in the B horizons which usually contain free carbonate. However, the deeper subsoils often become strongly acid ; in this feature they resemble closely the clays of the previous two associations (Groups 4 and 5).

Two associations have been distinguished but it was found very difficult to make a strictly pedological differentiation at the scale of mapping employed and to determine boundaries from aerial photographs. In this latter regard vegetation was found to be an important guide as in general soils which support a belah forest show a slightly lesser degree of solonisation and the subsequent effects of solodization than those soils which are characterised by a vegetation of poplar box and sandalwood. However, as mentioned earlier in the section on the vegetation, a further complication is introduced by the fact that the belah forests appear quite definitely to be invading the box-sandalwood regions. A very weak gilgai microrelief is often present in both associations but it is slightly stronger developed on the soils of the belah forests.

Group 6.—Weakly Solonised Brown Clay Loam Association.

Gross area 984,000 acres.

Weakly solonised brown clay loams supporting dense belah forests have a wide distribution, except in the Blythesdale sandstone area in the east and the south-west region between the Macintyre and Weir Rivers. They have their greatest development in the central and southern-central parts of the region and although present in the north they are not so extensively developed in the Tara–Glenmorgan area. The soils are usually closely associated with the grey and brown clays supporting brigalow (Groups 4 and 5) and there is every gradation between these clay loam surfaced soils supporting a vegetation dominated by belah and the clay soils dominated by brigalow.

The profiles are characterised by a fairly thin clay loam A_1 horizon of brown, grey-brown or occasionally reddish-brown colour. The A_1 horizon seldom if ever exceeds 5 inches in thickness and usually averages 2–3 inches. An A_2 horizon may or may not be developed but when present it is only an inch or less in thickness and weakly bleached. The presence of an A_2 horizon appears largely dependent on conditions of restricted surface drainage. The B_{21} horizon is well defined from the A and is normally a brown or grey-brown medium to heavy clay with a fairly coarse blocky to slightly prismatic structure. Consistence is hard when dry but does not exhibit the degree of toughness that characterises the weakly solodized-solonetz soils of the next association, (associated with a box-sandalwood vegetation), or the more normal solodized-solonetz soils of Group 13. Some free carbonate may be present in this horizon which merges gradually into the B_{22}. This lower B horizon has a blocky to massive structure, is somewhat more friable when moist and commonly has moderate amounts of free carbonate. Crystalline gypsum may be present in this horizon but more often it occurs below 30 inches, often abundantly. The deeper acid subsoils may become slightly sandy and display a dull orange or grey mottling. Excavated earth tanks and deep boring in these soils show that in some areas at depths ranging from 7 to 20 feet the strongly mottled red and white clays of the mottled zone of the old laterite profile are encountered. As mentioned for the soils of Groups 4 and 5 there is usually an observable break in the profile.

The following profiles illustrate the chief features of these soils supporting a belah forest :—

(i.) Profile approximately 5 miles north of Southwood on the Hannaford road—

A_1	0– 2 in.	Light-brown clay loam, slight platy to weak blocky, slightly hard, merges into
A_2	2– 3 in.	Light-greyish brown clay loam, slightly bleached, massive and vesicular, numerous grass roots, fairly sharply defined from

B_{21}	3–14 in.	Dark-brown medium to heavy clay, coarse prismatic structure, hard, merges into
B_{22}	14–24 in.	Dark-brown medium clay, blocky to massive, less hard, moderate amounts of carbonate nodules, merges into
BC	24–40 in.	Brown medium clay, slightly sandy, fairly friable, trace of carbonate, merges into
	40–60 in.	Brown medium to heavy clay, slightly sandy, firm to slightly plastic.

(ii.) Profile 3½ miles west of Weir River on the Lundavra road—

A_1	0– 4 in.	Brown clay loam, weak blocky, slightly hard, merges into
A_2	4– 5 in.	Light-brown clay loam, only faintly bleached, massive and finely vesicular, fairly sharply defined from
B_{21}	5–22 in.	Grey-brown heavy clay, coarse blocky, fairly hard, moderate carbonate nodules, merges into
B_{22}	22–30 in.	Greyish-brown medium clay, blocky to massive, fairly friable, moderate to abundant soft carbonate, merges into
BC	30–40 in.	Greyish-brown medium clay with moderate to abundant gypsum crystals and trace of carbonate.

(iii.) Profile 2 miles south-west of Yelarbon along the Kurumbul road—

A_1	0– 4 in.	Light-grey-brown clay loam, massive and fairly hard when dry, slightly bleached and vesicular at the base, fairly sharply defined from
B_{21}	4–15 in.	Dark-brown heavy clay, angular blocky, hard, merges into
B_{22}	15–24 in.	Brown medium clay, massive, fairly friable, merges into
BC	24–36 in.	Light-brown medium clay, friable with fairly abundant soft carbonate, merges into
	36–60 in.	Brownish-grey heavy clay with some dull orange mottling, fairly hard, merges into
	60–70 in.	Light-brown heavy clay with dull orange and grey mottling, firm to hard.

A weak gilgai formation may be present in these soils but the vertical interval usually does not exceed 4-6 inches. The puff profiles are usually identical with those described above but the depressions are often characterised by an absence or much thinner development of the clay loam A horizon and they may exhibit fairly extensive cracking.

Analytical Data—

Mechanical analyses show a distinct texture differentiation in the upper part of the profile. The A horizons are heavy loams to clay loams while the B horizons are medium clays (45 per cent. 2μ clay). The lower horizons show a decrease in clay content to values around 40 per cent. with a corresponding slight increase in the sand fraction. The reactions of the A horizons range from very slightly acid to neutral, the B horizons are neutral to moderately alkaline but in the deeper subsoils below 50 inches pH values commonly show a sharp drop to strongly acid conditions (pH 5·0). The slightly acid A horizons contain up to 30 per cent. of exchangeable hydrogen but the B horizon clays are almost fully saturated. As with the brigalow clay group the deep, strongly acid horizons are 60 to 70 per cent. saturated and thus it is difficult to explain their strongly acid nature. Calcium is normally the dominant exchangeable metal cation in the

A and B horizons; these soils thus have a better calcium status than the weakly solodized-solonetz soils of the next group. However both magnesium and sodium, particularly sodium, show a fairly sharp increase in the B horizon where sodium, although still subordinate to both calcium and magnesium, may constitute up to 20 per cent. of the total exchangeable metal cations. Total exchange capacities range from 65 to 80 m. equiv./100 gm. 2μ clay.

The chloride and total soluble salt contents are low to very low in the A horizons but increase sharply to moderate amounts in the B horizons and even higher values in the deeper subsoils (0·2 per cent. NaCl). Total nitrogen is in the vicinity of 0·1 per cent. for the A horizons while organic carbon is approximately 1·0 per cent., giving C/N ratios of the order of 10. Available phosphate in these soils ranges from low to moderate in the A horizons (see Table 12) but is generally very low in the B (less than 25 p.p.m. P_2O_5). Total phosphate ranges from 0·03 per cent. P_2O_5 in the A horizon to 0·01 per cent. in the B and slightly lower values continue with depth. Physical studies indicate that the A horizons of these soils have a very narrow range of available moisture between wilting point and field capacity. The B horizon clays have a fairly high wilting point (15–17 per cent.) but a wider range of available moisture (averaging 15 per cent.).

Vegetation—

The vegetation of this association is normally a belah forest, usually associated with some brigalow, *Geijera parviflora* and *Eremophila mitchellii*. A noteworthy feature is the often almost complete absence of a grass cover in these forests, the floor of which is often covered by fallen leaf litter (Plate 10).

Minor Associated Soils—

Due to photo-interpretation difficulties there are present in this association some areas of the grey and brown clays supporting brigalow. In some areas also the soils could have perhaps been included in the weakly solodized-solonetz group (Group 7) but have been retained in this association because they support a dense belah forest. In yet other instances there exist soils with fairly strong affinities with the red-brown earths.

GROUP 7.—WEAKLY SOLODIZED-SOLONETZ ASSOCIATION.

Gross area 471,000 acres.

The soils of this association have a widespread distribution but almost invariably bear a close relationship to both functional and non-functional drainage lines. This pattern is particularly clearly displayed in the south-west where these soils show an intimate relationship with the grey soils of heavy texture in the very flat areas that are subject to flooding. This pattern is clearly illustrated by aerial photographs (e.g. Plate 21). These areas of lighter textured surface soils are almost always in close proximity to both present and old drainage lines and they are normally slightly higher than the surrounding heavy grey clay areas. It would appear that these soils have developed on a parent material that was of slightly coarser texture than that of the heavy grey clays and thus permitted some leaching and clay eluviation. These soils then might be regarded as levee-type deposits as contrasted with the finer textured materials further away from the drainage lines.

It is likely that this relationship, so clearly displayed in this south-western area, offers an explanation for the distribution of these clay loam surfaced soils elsewhere in the region. Drainage lines that flow through the grey clay gilgai areas almost invariably have a narrow fringe of these weakly solodized-solonetz soils and this pattern is time and again repeated throughout the entire region.

Plate 21.

Aerial photo. (approx. scale 30 chains = 1 inch) of the region near Bungunya showing the close association of the weakly solodized-solonetz soils to an old drainage line which is now functional only during floods. The surrounding darker areas are the dark-grey heavy clays. (Group 2.)

Plate 22.

The weakly solodized-solonetz soils (Group 7) showing the characteristic scalded appearance and the occurrence of dead sandalwood. These areas are slightly higher than the surrounding dark-grey clays.

Like the soils of the belah forests these weakly solodized-solonetz soils have fairly thin clay loam A horizons which may or may not include a bleached A_2. The A_1 horizon is normally a brown to greyish brown (occasionally reddish brown) clay loam that does not exceed 6 inches in depth and is usually much less. An A_2 horizon if present is more strongly developed than in the belah soils and is more extensively bleached. Again the development of an A_2 horizon appears partly dependent on conditions of restricted surface drainage. The A horizons are fairly sharply defined from a grey-brown or browner clay B_{21} horizon which may display columnar structure, especially where a strongly bleached A_2 horizon is present. However, more often the structure is prismatic or coarse angular blocky. The consistence of this horizon is plastic when moist and very hard when dry and is much tougher than the corresponding horizon of the belah soils. The B_{22} horizon clay has a blocky or massive structure and usually contains free carbonate. The deeper subsoils may become slightly sandy. Gypsum does not appear to be very common in these soils. The following profiles illustrate their characteristics :—

(i.) Profile 1 mile south-east of The Deep crossing of the Moonie River, Southwood-Tara road.

A_1	0– 2 in.	Light-brownish-grey clay loam, slightly platy to weak blocky, fairly hard, fairly sharply defined from
B_{21}	2–12 in.	Grey-brown heavy clay, coarse prismatic to blocky, hard and tough and rather dense, grades into
B_{22}	12–22 in.	Greyish-brown heavy clay, rather massive, slightly friable, slight to moderate carbonate, merges into
BC	22–36 in.	Grey medium clay, slightly sandy, friable, merges into
	36–70 in.	Greyish-brown to brown medium clay, slightly sandy, firm to friable.

(ii.) Profile adjoining areas of grey soil of heavy texture, ¾ mile south of Toobeah—

A_1	0– 3 in.	Light-greyish-brown clay loam, weak blocky, fairly hard, slightly bleached at the base, fairly sharply defined from
B_{21}	3– 14 in.	Dark-brown heavy clay, coarse blocky, hard and tough, grades into
B_{22}	14– 48 in.	Grey-brown medium clay, fairly friable with moderate carbonate, merges into
BC	48– 70 in.	Brown medium clay, as above, merges into
C	70–100 in.	Yellowish-brown light clay, friable, slight to moderate carbonate nodules.

(iii.) Profile 1 mile east of Trevanna Downs station, north of Goondiwindi—

A_1	0– 6 in.	Light-brown sandy loam, weak blocky, soft to slightly hard, merges into
A_2	6–7 in.	Light-grey sandy loam (bleached), soft and massive, rather vesicular, sharply defined from
B_{21}	7–18 in.	Light-reddish-brown sandy clay with orange and grey mottling, hard and tough with well developed columnar structure with domed columns averaging 2–3 inches in diameter and with the bleached A_2 material filling the interstices and cracks between the columns. Grades into
B_{22}	18–26 in.	Brown sandy clay, angular blocky, slightly friable with moderate carbonate, merges into
BC	26–36 in.	Brownish to grey sandy clay with considerable carbonate.

This profile displays a much more typical solodized-solonetz morphology than is usual for soils of this association and the texture is somewhat coarser than normally occurs.

A very shallow gilgai development often accompanies these weakly solodized-solonetz soils but usually it is more weakly expressed than in the belah soils and it may frequently be entirely absent. The vertical interval between puff and depression is seldom greater than several inches. The puff profile is similar to profiles (i.) and (ii.) but the depressions normally have a darker coloured clay at the surface which may crack extensively.

Analytical Data—

Mechanical analyses show a similar texture contrast in the upper part of the profile to that occurring in the solonised brown clay loam soils but the deeper subsoils appear to have a higher clay content (50 per cent.) although not as high as in the subsoils of the frequently adjacent grey soils of heavy texture.

The A_1 horizon of these soils is usually slightly more acid than in the belah soils and in most instances the B_{21} horizon is slightly acid. The B_{22} is normally alkaline but as in the case of the belah soils the deep horizons may become strongly acid. However this is not the case in the south-west where the soils occur in close association with the grey soils of heavy texture. The B_{21} horizon clays show a lower degree of saturation (approximately 65 per cent.) than those of the previous belah soil group but the B_{22} horizons are normally fully saturated. Calcium is the dominant exchangeable metal cation in the A horizon but in the B (in contrast to the belah soils) magnesium is more likely to be dominant. Exchangeable sodium also shows an appreciable rise in the B horizon, again up to 20 per cent. of the total exchangeable metal cations. It is to be noted that these soils have a better calcium status than the more typical solodized-solonetz soils of Group 13 but normally less than in the weakly solonised brown clay loams.

The chloride and total soluble salt contents are very low in the A horizons but show some accumulation in the B and deeper horizons although values are somewhat less than in the belah soils. Total nitrogen in the A horizon is again in the vicinity of 0·1 per cent. or slightly higher with a C/N ratio of 10 to 14. Available phosphate is normally low but appears to show some variation in the A horizons. Physical studies indicate that the A horizons of these soils have a fairly narrow range of available moisture while that of the B horizon tends to be somewhat less than in the corresponding horizons of the belah soils. Field observations following rain have indicated that the B horizons of these soils are very impervious to water, apparently due to the dispersed nature of the clay. In this regard they appear to be much less permeable than the belah soils.

Vegetation—

The vegetation of these soils is characterised by the invariable presence of sandalwood (*Eremophila mitchellii*), usually accompanied by *Eucalyptus populnea* and *Geijera parviflora*. In contrast to the soils of the belah forests these weakly solodized-solonetz soils normally have a short but fairly dense grass cover of species of *Chloris*.

Minor Associated Soils—

The chief minor soils of this association are red-brown earths which have been slightly solonised and which possess a rather thinner A horizon than normally. In some areas, particularly in the south-west, there may be included in this association as mapped some deep sands and the sandy soils of the solod-solodic-solodized-solonetz association. In other areas they may grade into the more normal solodized-solonetz association of Group 13.

(*e*) RED-BROWN EARTHS.

Soils conforming to descriptions of this great soil group (Prescott 1931, Stephens 1953) occur in the region but more particularly towards the west where the rainfall decreases to the vicinity of 20 inches annually. In many occurrences the red-brown earths have been slightly solonised so that profile morphology may resemble that of a solodized-solonetz. This similarity of morphology of these two soil groups appears common in inland Australia ; Downes and Sleeman (1955) in particular have drawn attention to this fact and have even suggested that the red-brown earths and the solodized-solonetz could be combined as a single great soil group.

Group 8.—Red-Brown Earth Association.

Gross area 114,000 acres.

Throughout the region the red-brown earths are most commonly found on alluvial parent material and in some cases they are under-lain by the old truncated laterite profile. Where formed from alluvium the distribution of the red-brown earths conforms closely with the drainage pattern, there being a marked association with those streams which head in areas where there are numerous lateritic residuals. However, there also appears to be a broad zonal factor affecting their distribution. Thus the more typical red-brown earths are largely confined to the western slightly lower rainfall parts of the region. In the south-eastern areas alluvial soils having some characteristics of the red-brown earths have been described as sub-mature red-brown earths (Group 1), but these are characterised by a much deeper A horizon from which a reddish colour is absent and by the fact that free carbonate only occurs in the deeper subsoils.

The red-brown earths usually have a fairly marked profile differentiation with colour and textural differences demarcating the A and B horizons. The A_1 horizon ranges in thickness from 6 to 10 inches and is reddish-brown in colour, the texture being a loam or clay loam. An A_2 horizon is normally not present except where there have been some factors causing restriction of surface drainage. In such instances the A_1 horizon does not normally exceed 6 inches and the bleached A_2 is a light-greyish-brown clay loam which is seldom more than an inch thick. The B horizon is a light to medium clay and a brighter reddish-brown or red-brown in colour. The deeper subsoils are usually lighter in colour, often with a yellowish tint. Free carbonate is invariably present in the B and BC horizons and is very occasionally present in the A. Scattered throughout many profiles are small ferruginous nodules ; these are mainly present where the red-brown earths have developed in proximity to lateritic residuals. The nodules may occasionally be more concentrated on the surface. The following profiles illustrate the more important features of the red-brown earths :—

(i.) Profile 3 miles north-west of Springmount turn-off, Bungunya–Surat road.

A_1	0–10 in.	Light-reddish-brown clay loam, dry, slightly hard, weak blocky, fairly well defined from
B_{21}	10–26 in.	Red-brown light clay, moderate blocky, friable, small soft ferruginous nodules, trace of carbonate, merges into
B_{22}	26–30 in.	Reddish-brown medium clay, blocky to massive, friable, slight soft ferruginous nodules, moderate soft carbonate.

(ii.) Profile 2 miles south-west of Coomoomie Station, approximately 14 miles south-south-west of Glenmorgan.

A_1	0– 7 in.	Light-reddish-brown clay loam, dry, slightly hard, weak blocky, occasional small ferruginous nodules, trace of carbonate, fairly well defined from
B_{21}	7–15 in.	Dark-reddish-brown medium clay, firm to hard and massive, trace of carbonate, merges into
B_{22}	15–30 in.	Red-brown medium clay, friable, moderate carbonate nodules, merges into
	30–54 in.	Reddish-brown medium clay, fairly friable, trace of carbonate, isolated small ferruginous nodules. Fairly sharp change to
	54–62 in.	Light-reddish grey-brown clay, rather gritty with decomposing ferruginous material and much white kaolinitic material. This is evidently mottled zone material.

Although this soil appears at first glance to have developed in situ from the mottled zone of a truncated laterite profile it is most likely that the soil has developed from material that has been deposited as a cover on the old eroded lateritic surface. This would certainly seem necessary to explain at least the presence of the free carbonate in the profile. Further evidence is afforded by a deep profile south of Meandarra which showed that, in this instance at least, a fairly typical red-brown earth may be underlain by the ferruginous zone of the old laterite profile. Another interesting feature of this profile is that the subsoil material above the old laterite profile is strongly acid and thus closely resembles the previously mentioned strongly acid subsoils which occur beneath other soil groups in the region.

Profile approximately 14 miles south-south-west of Meandarra near Brigalow Creek—

A_1	0– 8 in.	Light-brown clay loam, weak blocky, fairly hard, fairly sharply defined from
A_2	8– 9 in.	Light-brownish-grey clay loam (bleached), massive, vesicular, isolated ferruginous nodules, sharp change to
B_{21}	9–14 in.	Brown heavy clay, medium blocky and hard, merges into
B_{22}	14–24 in.	Lighter-brown medium clay, less hard, merges into
B_{23}	24–40 in.	Light-brown medium clay, medium blocky, friable, slight to moderate carbonate. Merges into
	40–60 in.	Brown medium clay, friable, trace of carbonate, some black manganiferous fleckings, merges into
	60–81 in.	Dull-brown to slightly reddish-brown medium clay, friable, moderate development of clay skin surfaces on aggregates, some ill-defined grey mottling. Merges into
	81–84 in.	Brownish-red clay, somewhat sandy with some rounded ironstone pebbles and red mottling. This zone is apparently the interface of the underlying ferruginous horizon which begins quite sharply
	84–114 in.	Red sandy clay to sandy clay loam with at first some brown slightly more clayey patches and occasional small grey mottles. At 96 inches is pure red sandy clay loam material, at 102 inches is a band of small ironstone nodules, from 102 inches to 114 inches colour is rather brownish-red with some greyish mottling appearing. This is all evidently ferruginous zone material which grades into the mottled zone around 114 inches but the boundary is very diffuse.
	114–132 in.	Mottled zone material, sandy clay loam in texture with mottled patches of red sandy clay loam and more typical greyish kaolin-like material. A nearby excavated earth tank shows that at greater depths (approximately 15 feet) this mottled zone material is the more typical heavy clay with strong mottling which is friable when moist but on exposure to the air becomes very hard.

There is little doubt that the material below 84 inches is an old buried profile and bears no relationship in terms of soil formation to the overlying material from which the red-brown earth has developed. Further discussion of this feature is reserved until a later section.

Red-brown earths with a profile resembling that of a solodized-solonetz occur in association with the more normal types but quite often they are restricted to lower depressed areas where surface drainage is somewhat restricted. In these instances the B_{21} horizon is tougher than in the more normal red-brown earths but there is no evidence of any development of columnar structure.

Analytical Data—

The A horizon of the red-brown earths is usually neutral but there is commonly a rise in pH to 8 or slightly higher in the B horizons. Some profiles may become strongly acid in the deep subsoils. The acid (pH 5·0 or less) decomposing mottled zone material underlying some soils contains 50 per cent. exchangeable hydrogen and also has a comparatively low total exchange capacity. This lower degree of saturation is more in keeping with what might have been expected for the strongly acid horizons beneath the other soil groups discussed earlier.

In the Brigalow Creek profile described earlier the extremely acid (pH 4·4) ferruginous material that apparently represents the upper horizon of an old laterite profile is still 56 per cent. saturated but has a comparatively low total exchangeable metal ion content (8.5 m. equiv./100 gm. soil), this is much lower than in the overlying soil profile, and it is evident that both this and the underlying mottled horizon consist largely of kaolinitic clays.

Calcium is the dominant exchangeable metal cation in the A horizon of the red-brown earths but in the B and lower horizons magnesium may range from subdominant to dominant. Exchangeable sodium increases with depth, usually to significant amounts in the B and lower horizons. Exchangeable potassium is higher than normal in the A horizon. The chloride content of the subsoils is often moderately high and may range up to 0·2 per cent. NaCl. In the A horizon organic carbon ranges from 1·0 to 2·0 per cent. and total nitrogen is usually slightly greater than 0·1 per cent. Available phosphate in the A horizon is variable but generally higher than in most of the other soils, ranging from 40 to 260 p.p.m. P_2O_5 but values show a marked drop to low levels in the deeper horizons.

Vegetation—

The vegetation of the red-brown earths is typically a woodland of *Eremophila mitchellii* and *Eucalyptus populnea*, with usually also *Eremocitrus glauca* and *Casuarina lepidophloia* (belah). The grass cover is almost invariably dominated by *Chloris spp.* There is quite strong evidence to indicate that belah is invading some of these *Eremophila mitchellii*—*E. populnea* communities so that the total area of red-brown earths is probably somewhat greater than that shown on the soil map owing to the difficulty of distinguishing on aerial photographs red-brown earths now carrying a dense stand of invading belah from the more typical brown clay loams of the older belah forests.

Minor Associated Soils—

Where the red-brown earths are underlain by the mottled zone of the truncated laterite profile they frequently form part of a catenary sequence so that on the one side they often grade into the lateritic red earths and on the other they may merge into the weakly solodized-solonetz soils or the brown brigalow clays. Where developed on alluvial material they are usually associated with the weakly solonised brown clay loams or the grey and brown soils of heavy texture.

(*f*) LATERITIC RED EARTHS.

Acid red soils developed on or forming part of the old laterite profile have been classed as lateritic red earths (Stephens 1953, Stewart 1956). This term is equivalent in part with the latosols of the American literature (e.g. Kellogg 1949). In Australia the terms " red loams " and " red earths " have often been rather loosely used but the general tendency has been to restrict the term red earth to less porous red soils that do not have the well structured profile of the red loams.

Group 9.—Lateritic Red Earth Association.

Gross area 232,000 acres.

Lateritic red earths are commonly found throughout the region wherever outcrops of the old Tertiary laterite profile occur. In most instances these outcrops are of mottled zone material and on these lateritic red earths of variable profile depth have apparently developed. However, in some areas these red soils may represent the upper ferruginous part of the laterite profile. The soils are invariably characterised by a thin scattered surface veneer of small ironstone nodules which may be concentrated locally by surface drainage conditions. The soils range in depth from about 24 inches to over 6 feet depending mainly on the altitude of various parts of the lateritic outcrop. The profile normally shows some texture differentiation as the A horizon, ranging from 8 to 12 inches in thickness, is invariably a clay loam while the B is usually a light clay. Colour throughout the profile is generally a light-red or reddish-brown but may become yellowish-brown or orange at depth. As a rule there are no sharply defined colour, structural or textural horizons. Small ferruginous nodules are always present throughout the profile and in some instances form a strong hardpan at shallow depths. The following profiles illustrate the features of these lateritic red earths :—

(i.) Profile 1 mile west of Wybar Station, approximately 30 miles north of Goondiwindi.

0– 8 in. Light-reddish-brown clay loam, friable, weak blocky, slight ferruginous nodules. Merges into

8–24 in. Light-red clay loam—light clay, soft to friable, slight to moderate ferruginous nodules, fairly sharp break to

24–36 in. Light-red to orange light clay with a heavy hardpan-like accumulation of ferruginous nodules averaging ¼-inch in diameter.

(ii.) Profile near Lienassee Station, 4 miles south of the Moonie Highway on the Goondiwindi–Meandarra road.

0– 8 in. Light-reddish-brown clay loam, weak blocky, slightly hard, isolated ferruginous nodules. Grades into

8–24 in. Light-red clay loam—light clay, weak blocky, friable, trace of ferruginous nodules, merges into

24–36 in. Light-brownish-red light clay, fairly hard, moderate ironstone nodules, some dull-grey and yellowish-grey mottling, merges into

36–52 in. Yellowish-brown light clay, more friable, slight ironstone nodules, some dull greyish and reddish mottling, merges into

52–54 in. Red and grey mottled medium clay, friable, fairly sharp change to

54 in.+ Hard red and grey mottled zone material.

In some areas the lateritic red earths may be quite shallow where the truncated laterite profile is close to the present day surface. Thus a profile 2½ miles west of Glenmorgan on the Surat road shows :—

0–10 in. Light-reddish-brown clay loam, weak blocky, slightly hard, isolated ferruginous nodules. Fairly sharply defined from

10–18 in. Light-reddish-brown clay loam—light clay, mottled yellow and grey, hard and massive, moderate to abundant ferruginous nodules, grades into

18–24 in.+ Decomposing mottled zone material.

Analytical Data—

The soils are acid throughout the profile, the pH of the A horizon ranges from 4·5 to 5·5 and is normally lower than elsewhere in the profile. Reaction values tend to rise slightly in the 24–36 inch zone, ranging from 5·6 to 6.6. The total exchangeable metal cations are quite low (not exceeding 8 m. equivs. per 100 gm. soil). Calcium is predominant but magnesium may show a rise with depth. Exchangeable sodium is low throughout. Total soluble salts and chlorides are fairly low, as also is nitrogen. Available phosphate is very low in all horizons (less than 25 p.p.m. P_2O_5). Physical studies indicate a very narrow range of available moisture between wilting point and field capacity.

Vegetation—

The vegetation of the lateritic red earths is usually a characteristic woodland community of *Eucalyptus melanophloia*, *E. populnea* and *E. crebra* with occasional stands of *Callitris glauca*. The ground flora is dominated by *Aristida jerichoensis* and *A. caput-medusae*.

Minor Associated Soils—

The lateritic red earths frequently occupy part of a catenary sequence and this is particularly evident on the gently sloping cuesta-like lateritic residuals. Near the escarpment edge, which is normally the highest part of the sequence, shallow lithosolic soils occur with numerous lateritic outcrops. These gradually deepen down the slope and assume a degree of profile development giving eventually the typical lateritic red earths. These in turn may grade in to red-brown earths at lower levels of the catena, or even, occasionally, solodized-solonetz soils if locally depressed areas with restricted drainage occur. In other areas the lateritic red earths may adjoin the grey brigalow clays with often only a narrow transitional zone of brown or reddish-brown clays.

(*g*) DEEP SANDS.

Scattered throughout the region are small occurrences of deep sandy soils which show very little or no textural change with depth and have a reaction which is usually slightly acid to neutral. Similar soils in the Macquarie region, New South Wales, although more strongly acid in reaction, were called sandy solodized soils by Downes and Sleeman (1955) while in the preliminary survey of the resources of the adjacent Namoi region (1950) they were called deep sands. It appears that in most instances in this Queensland region these deep sandy soils represent relict aeolian deposits and their depth is usually related to their elevation above their surroundings. In view of the general lack of profile development there would be some justification for classing these deep sands as regosols. For the sake of clarity and uniformity with New South Wales designation they will be called " deep sands " although it is not suggested that this unit should be recognised as a separate great soil group.

Group 10.—Deep Sands Association.

Gross area 19,000 acres.

The deep sands occur in the form of fairly small slightly elevated deposits which in most cases appear to represent relict sand dunes. They are most common in the south-west but also occur, although much less frequently, in the central and southern parts of the region. Although the length of the individual areas normally exceeds their breadth they do not appear to have any apparent orientation. In all cases these deposits are fixed by vegetation.

The sands usually have a loose unconsolidated surface and the sandy texture is uniform throughout the profile although around 5 to 6 feet there may occasionally be a few nodules of weakly cemented clayey sand which may represent a rudimentary textural B horizon. Below this zone the texture is again sand. The colour of the sand is usually a light shade of brown or greyish-brown with sometimes at depth some patches of reddish-brown mottling. A fairly shallow perched watertable is often present in these deposits. The following profiles illustrate the characteristics of these sands :—

(i.) Profile 1½ miles west of the Weir River, Goondiwindi-Lundavra road.

0–48 in.	Brown sand, loose, single grain. Grades into
48–60 in.	Light-brown sand, loose, single grain, merges into
60–72 in.	Brownish-grey sand with patches of reddish-brown mottling.

(ii.) Profile 8 miles south of Toobeah, Bollaranga road.

0–10 in.	Light-greyish-brown sand, loose, single grain, grades into
10–60 in.	Light-brown sand, loose, single grain, merges into
60–72 in.	Light-brown sand with weakly-compacted yellowish brown clayey sand nodules.
72–80 in.	Light-brown sand continuing.

Plate 23.
Slightly elevated relict sand dune 8 miles south of Toobeah. The dune is now fixed and supports a tall community of Moreton Bay ash and occasional poplar box. The sand is deep and quite loose.

Plate 24.
More elevated sand ridge 22 miles north-north-west of Yelarbon, here supporting a vegetation of rusty gum, cypress pine, Xanthorrhoea and blady grass.

Analytical Data—

The sands usually range from slightly acid to neutral in reaction although the Weir River profile showed values rising to over pH 8 in the 2–4 foot zone. The total soluble salts also showed an appreciable rise for these horizons. There is a very low total content of exchangeable metal cations, magnesium being dominant with exchangeable sodium very low. Available phosphate is often not as low as might be expected (40–50 p.p.m. P_2O_5) but nitrogen is very low. Chlorides are extremely low throughout the profile.

Vegetation—

The sands usually carry a fairly dense stand of tall trees, the chief species being *Eucalyptus dealbata, E. tessellaris, E. populnea, Callitris glauca and Acacia excelsa.* However, the grass cover is sparse, consisting mainly of species of *Aristida* and *Eragrostis.*

Minor Associated Soils—

Towards their margins these deep sands develop a tough and compact clay B horizon at depths which become progressively shallower. This leads to soils with a typical solodic and solodized–solonetz morphology. A mapping difficulty frequently encountered was whether to map certain sandy areas recognised on aerial photographs as the deep sands or the shallower sandy solodic soils with a compact B horizon as it was not possible to investigate every occurrence. This was further complicated by the fact that these two soil groups are often closely associated geographically.

(*h*) SOLOD, SOLODIC AND SOLODIZED–SOLONETZ SOILS.

Soils with a very distinct sharply demarcated textural B horizon often displaying strong columnar structure and with usually an associated bleached A_2 horizon occur commonly throughout the region. The A horizons of these soils are always acid, often quite strongly so, while the B horizons may range from fairly strongly acid to moderately alkaline. In all profiles the predominant exchangeable metal cation of the subsoils is magnesium, with sodium also significant. Morphological and chemical characteristics thus indicate that these soils range from a solodized–solonetz to a solod.

In recent years the term solodic has been increasingly used in Australian soil literature for soils showing certain features of podzol-like or solod-like morphology but at present there does not appear to be a well established defined distinction between such soils and the solodized solonetz and the solod. Hallsworth *et al* (1953) state that the solods have the general morphological characteristics of the solodic soils and may be distinguished at present only by their chemical characteristics, the chief feature of distinction being that they are acid throughout. On the other hand the same authors state that the solodic soils and the solodized–solonetz are mainly to be distinguished by the lack of columnar structure in the B horizon of the solodic soils, both being characterised by an acid A horizon and a B horizon which is normally alkaline. Thus there is some confusion in terminolgy as some authors, e.g. Downes and Sleeman (1955), have applied the term solodic to sandy surfaced soils showing a solod-solodic morphology but which are acid throughout.

For the present in the following description of soils showing characteristics of a solod, solodic and solodized-solonetz the terminology of Hallsworth *et al* (1953) is generally followed. However, the presence of columnar structure in the B horizon has been found to occur, although in a modified form, in some soils which are acid throughout. Thus soils assigned to these three groups are not to be expected to always conform exactly to their defined limits. This is normally to be expected as each individual soil group apparently represents a stage in a sequence that ranges between two end members. The diagnostic features of columnar structure and pH are difficult to establish in all occurrences in reconnaissance surveys so that the mapping units are often difficult to define precisely in terms of their taxonomic units. Thus in the following descriptions the solods are normally acid throughout but with a B horizon that may occasionally display columnar structure, the solodic soils normally have an alkaline B horizon without columnar structure, while the solodized-solonetz soils normally have an alkaline B horizon usually with a strong development of columnar structure. Four associations have been defined on this basis, the occurrence of solodized-solonetz soils being so widespread as to justify a further subdivision based mainly on depth and texture of the A horizon.

It might be mentioned here that the emphasis placed on the presence or absence of columnar structure as a diagnostic feature of this group of soils may be based on a premise that is more apparent than real. There is evidence to indicate that this property is related to some extent to the textural and drainage characteristics of the A horizon of the soil concerned. Thus columnar structure is frequently more strongly developed in soils which have a freely drained coarse textured A horizon that is subject to periods of intensive wetting and drying. Burvill and Teakle (1938) have earlier made a similar observation for certain soils in Western Australia that possess a well developed columnar structure. It is the view of the writer that a distinction between solodized-solonetz and solodic soils based mainly on the presence or absence of columnar structure is totally inadequate. There is an urgent need for a clearer and more workable definition of these two groups of soils if they are to be distinguished at the great soil group level.

GROUP 11.—SANDY SOLOD–SOLODIC–SOLODIZED–SOLONETZ ASSOCIATION.

Gross Area 296,000 acres.

The soils of this association are characterised by normally quite deep sandy A horizons and a sharply demarcated dense sandy clay loam or sandy clay B horizon. The association has its greatest development in the east of the region where it is extensively developed on the sandstones of the Blythesdale Group. However, a number of occurrences are present elsewhere where they appear to be derived from sand deposits that have been accumulated either by alluvial or aeolian agencies. The soils normally occur on flat to gently sloping surfaces but occasionally there may be undulating sandy ridges, such as north of Inglewood.

In this association the solod and the solodized-solonetz appear to be most common. The solods have a deep sand or loamy sand A horizon varying from 20 to 50 inches. The surface is rather loose to slightly compacted and the colour of the A_1 horizon is brown, light-brown or light-greyish-brown. The A_2 horizon has a variable development ; it may be thick (up to 12 inches), rather ill-defined and only slightly bleached or it may be a strongly bleached thin horizon capping the B with the bleach " eating into " the clay below. Quite often the bleached A_2 contains small ferruginous nodules and has a faint yellowish or rusty mottling. The B_2 horizons are sharply demarcated from the A and are usually a dense sandy clay loam or sandy clay. The B_{21} may display a fairly coarse columnar structure but more often it is prismatic or massive. Consistence is extremely hard and tough when dry. Gleying effects are frequently developed with pronounced grey and yellow mottling rather common. Often there are moderate amounts of ferruginous nodules. The B_{22} horizon usually has a massive structure, with less tough consistence and lesser evidence of gleying. Ferruginous nodules may again be present. The colour of the B horizon is somewhat variable but frequently becomes yellowish with depth when decomposing sandstone may be encountered. The following solod profiles indicate the chief characteristics of this group of soils :—

(i.) Profile 8 miles east-north-east of Yelarbon along the railway line.

A_1	0– 6 in.	Brown loamy sand, single grain, loose, pH 6·0, merges into
A_{21}	6–18 in.	Light-brown sand, single grain, loose, pH 5·5, merges into
A_{22}	18–20 in.	Pale-brown slightly bleached sand, moderate ferruginous nodules, pH 6·1, sharply demarcated from

B_{21} 20–26 in. Greyish-brown dense sandy clay, strongly mottled bluish-grey, grey and yellow, fairly coarse columnar to prismatic structure with the A_2 bleach partly "*eating into*" the clay and filling the interstices between the gently domed columns. Tough to hard consistence, numerous ferruginous nodules, pH 5·5, merges into

B_{22} 26–36 in. Yellowish-brown sandy clay, darker yellow or rusty mottling, massive, less tough, moderate ferruginous nodules, pH at 36 inches is 7·4. Merges into

BC 36–50 in. Brownish-yellow sandy clay loam with moderate ferruginous nodules and some gravel, pH at 50 inches is 8·0.

(ii.) Profile 8½ miles east-north-east of Yelarbon along the railway line.

A_1 0– 6 in. Brown sand, fairly coarse, single grain, loose, pH 5·1. Merges into

A_{21} 6–22 in. Light-brown sand, single grain, loose, weak rusty mottling, pH 5·0, merges into

A_{22} 22–30 in. Light-greyish-brown loamy sand, slightly bleached, loose, faint yellowish and rusty mottling, pH 5·3. Sharply demarcated from

B_2 30–48 in. Light-yellowish-brown sandy loam—sandy clay loam, strongly mottled grey and yellow, massive, tough and compacted, pH 5·6

48 in. + *Decomposing yellowish sandstone.*

(iii.) Profile 6 miles south of the Moonie Highway along the Weir Highway.

A_1 0–12 in. Light-greyish-brown sand, single grain, loose pH 6·4. Merges into

A_2 12–54 in. Pale-brownish-grey sand becoming almost white with depth, single grain, loose, pH ranges from 6·5 in 21–24 inch zone to 5·8 in 46–54 inch zone. Sharply demarcated from

B_2 54–60 in. Yellowish-brown clayey sand—sandy clay loam with grey and yellow mottling, massive, hard and cemented, pH 5·9.

The solodized-solonetz profiles are usually characterised by shallower sandy A horizons which may be less than 12 inches thick. The surface soil is more compact than in the solods. The A_2 horizon is well developed and fairly strongly bleached. The B_{21} is a dense sandy clay, hard and tough, with a well developed columnar structure. Gley effects do not appear to be so commonly developed but this may be partly a result of the shallower A horizons. Slight amounts of free carbonate may be present in the B_{22} horizon. The following profile is characteristic :—

A_1 0– 4 in. Light-greyish-brown sand, compact surface then single grain and loose, numerous grass roots, pH 5·5. Merges into

A_2 4– 7 in. Grey sand (bleached), porous, slightly compacted, pH 5·8, sharply demarcated from

B_{21} 7–18 in Light-yellowish-brown dense sandy clay with a trace of grit, fairly hard with well developed columnar structure, the domed columns averaging 3 inches in diameter, pH 7·3. Merges into

B_{22} 18–33 in. Bright-yellowish-brown sandy clay, massive, friable, trace of carbonate and quartz grit, pH 8·2.

33 in.+ Continuing to at least 40 inches with increasing amounts of coarse grit.

With the exception of (iii.) the above profiles are of soils derived mainly from sandstones of the Blythesdale Group. However there are numerous smaller occurrences of these soils scattered throughout the region and many of these are probably in part at least of aeolian origin. Thus in the vicinity of The Gums a sandy solod occurs in a region almost entirely occupied by the clay soils of Group 4. The following profile is at 0·5 miles east of The Gums school :—

A_1	0– 24 in.	Light-brown sand, loose, single grain, grades into
A_2	24– 32 in.	Pale-brownish-grey bleached sand, slightly compacted, sharply demarcated from
B_2	32– 40 in.	Yellowish-brown-mottled-grey sandy clay, dense, hard and cemented. Apparently massive structure, pH at 36 inches is 5·0–5·5. Merges into
BC	40– 72 in.	Grey medium to light clay with yellowish-brown sandy clay loam patches. The grey clay is friable when moist and has well developed clay skin surfaces. pH at 48 inches is 6·0–6·5, at 60 inches is 6·5–7·0. Merges gradually into
	72– 96 in.	Yellowish-grey-brown sandy clay loam, mottled grey (clayey) and brown and occasionally orange. Very little clay skin development. Very friable. Merges into
	96–120 in.	Light-yellowish-grey-brown sandy loam with some grey sandy clay loam patches and some rusty sandy mottling. Merges into
	120–138 in.	Brownish-grey sandy clay loam with some rusty and grey mottling. Firm and compacted but somewhat friable. Merges into
	138–156 in.	Fairly coarse light-brownish-grey sandy clay loam-sandy clay with some rusty and grey mottling. Compacted.

It is of interest to note that the lower horizons of this soil are alkaline in contrast to the strongly acid conditions obtaining at relatively shallow depths in the surrounding grey clay areas. Somewhat similar soils exist to the west of the Weir River in the vicinity of Goodar and in a deep profile there from 30 inches to 60 inches the material is a sandy clay loam, from 60 inches to 84 inches a loamy sand or sandy loam, from 84 inches to 120 inches a light-grey to light-greyish-brown light clay with slight to moderate carbonate and from 120 inches to 156 inches a dark-greyish-brown medium clay, friable and with carbonate along the cleavage planes. This deeper material again bears little resemblance to the acid sub-soil clays that occur in close but not immediate proximity.

Solodic soils do not appear to be as common in this association as the solods and solodized-solonetz but if they are only to be differentiated on the basis of an alkaline B horizon without columnar structure it is difficult in a reconnaissance survey to fully estimate their extent. In morphology they resemble the solod and the solodized-solonetz. For these reasons they will be discussed more fully in the next association where they appear to play a more prominent role.

Analytical Data—

As seen from the profile description the solods are acid throughout the A and B horizons, often strongly so, but occasionally they may become alkaline in the deep subsoils of some profiles. The B horizon clays are unsaturated (30 to 50 per cent. saturation) with magnesium by far the dominant exchangeable metal cation. Exchangeable sodium is also fairly high, these two together forming up to 90 per cent. of the total exchangeable metal cations, the exchangeable calcium being negligible. Chlorides and total soluble salts are usually negligible although they may show a slight accumulation in the deep subsoils. Total nitrogen and available phosphate are low.

The sandy surfaced solodized-solonetz soils of this association have moderately acid A horizons but the pH rises with depth to over 8 in the B_{22} horizon where free carbonate occurs. The A horizons are again unsaturated but in contrast to the solods the B horizons are 80 per cent. saturated. Magnesium is again the dominant exchangeable metal cation throughout, commonly averaging 50 per cent. of the total metal ions. Sodium shows a marked rise with depth up to 5·6 m. equiv. per 100 gm. soil, (36 per cent. of the total metal cations) in the B horizon. Exchangeable calcium, although greatly subordinate to magnesium and sodium, is not as low as in the solods. Chloride and total soluble salts are higher than in the solods but not unduly so, the highest levels occurring in the B_{22} horizons. Available phosphate is very low.

Vegetation—

The soils of this association have a very characteristic forest vegetation dominated by cypress pine (*Callitris glauca*), although bull oak (*Casuarina leuhmannii*) and *Eucalyptus crebra* and *E. dealbata* are generally associated. The grass cover is usually rather sparse.

Minor Associated Soils—

Throughout the belt of sandy country characterised by the soils of the above association there are isolated areas of deep sandy soils which do not show any evidence of clay accumulation—the deep sands of Group 10. These occurrences are usually slightly elevated with a very loose surface. Also occurring as minor associates, especially in less well drained sites, are the clay loam surfaced solodized-solonetz soils of Group 13. Where sandstone and lateritic outcrops occur there may be small areas of shallow lithosolic soils and in addition there are some soils which show a podzolic rather than a solodic morphology, with a more diffuse boundary between the A and B horizons and some evidence of sesquioxide accumulation. Such soils are acid throughout the profile.

Group 12.—Sandy Solodic Association.

Gross area 25,000 acres.

This association is of limited extent and is developed on the sandstones of the Moonie Formation, typically in the vicinity of Westmar on the Moonie Highway but also further east towards Parkhurst. The association is developed on fairly high gently undulating ridges, the crests of which may have sandstone outcrops.

The solodic soils have fairly deep A horizons which may range from a loamy sand to a sandy clay loam in texture. The A_1 horizon averages 10 to 15 inches and is usually light-brown in colour. A bleached A_2 horizon some 3 inches thick is present and this is sharply demarcated from a dense massive clay B_2 horizon which may have a trace of carbonate at its lower limits. The colour of this hard and tough B_2 is grey-brown with often some grey and yellow mottling and some ferruginous nodules. In some profiles there may be a ferruginous hardpan at depth. The following profiles illustrate the chief features of these solodic soils :—

(i.) Profile 1 mile east of Westmar, Moonie Highway.

A_1	0–15 in.	Light-brown loamy sand, fairly coarse, compacted surface then single grain to very weak blocky, soft, pH 5·3. Merges into
A_2	15–18 in.	Brownish-grey to grey sand (bleached), massive and rather porous, soft, pH 7·5. Sharply demarcated from
B_{21}	18–26 in.	Grey-brown medium clay, slightly sandy, some yellow mottling, massive, extremely hard and tough when dry, some ferruginous nodules. pH 7·5. Merges into
B_{22}	26–36 in.	Yellowish-brown medium clay, massive, hard but slightly more friable than the B_{21} horizon. Small black stainings. pH 8·3. Merges into

BC 36–50 in. Yellow-brown sandy clay-sandy clay loam with yellowish-red and grey mottling, fairly friable, some ferruginous nodules. pH 8·5.

50 in. + Hardpan of ferruginous material.

(ii.) Profile 4½ miles west of Westmar, Moonie Highway.

A_1 0–11 in. Light-brown sandy clay loam, weak blocky, slightly hard, compact surface, merges into

A_2 11–13 in. Light-greyish-brown sandy clay loam, only slightly bleached, massive, slightly hard, sharply defined from

B_{21} 13–18 in. Grey-brown medium clay, slightly sandy, weak grey and yellow mottling, massive, hard and tough, very dense. Merges into

B_{22} 18–36 in. Greyish-brown to brown light clay, slightly sandy, massive, fairly hard, trace of carbonate.

Analytical Data—

These solodic soils have fairly strongly acid A_1 horizons, an A_2 which may be acid or neutral, and moderately alkaline B horizons. The B horizon clays show a high degree of saturation (80 per cent.) and the exchangeable cations are dominated by magnesium with sodium also fairly prominent. Exchangeable calcium is rather low but higher than in the solods or sandy solodized-solonetz. Chlorides and total soluble salts are also fairly low but show a slight accumulation in the B and BC horizons. Available phosphate is low (less than 30 p.p.m. P_2O_5).

Vegetation—

The vegetation of these solodic soils is a woodland of *Eucalyptus melanophloia, E. populnea, Callitris glauca* and *Petalostigma pubescens.*

Associated Soils—

This association is of necessity a rather broad one as due to variation in topography there is some related variation in soils. On the crests of some ridges sandstone outcrops occur, sometimes lateritised, and these give rise to fairly shallow lithosolic soils which are often red in colour. Where more mature these develop typical lateritic red earth features. On the slopes of some of these ridges a forest of lancewood (*Acacia sparsiflora*) is occasionally developed and the soils are rather different to those described above. The following profile is illustrative :—

Profile of soil supporting a lancewood forest, Moonie Highway, approximately 1 mile north-west of Parkhurst Station.

A_1 0– 8 in. Brown sandy loam, compact surface, single grain, merges into

A_{12} 8–20 in. Dull-reddish-brown sandy loam, soft and fairly loose, merges into

B_{21} 20–33 in. Dull-orange sandy clay loam, massive, soft to friable, merges into

B_{22} 33–36 in. Orange sandy clay loam, faint red and grey mottling, massive.

Another soil type found in limited areas in this association (although more extensively developed west of the survey limits), consists of a deep light-red fine sandy loam which does not show any profile differentiation. This soil appears to be related to the lateritic red earths and has a characteristic vegetation of *Casuarina inophloia, Eucalyptus trachyphloia* and *E. dealbata.* In some areas these red sands may support the spinifex *Triodia mitchellii var. pubivagine* as well as a dense stand of *Aristida spp.*

Finally around the margins of this association the solodic soils frequently merge into the sandy surfaced solod-solodic-solodized-solonetz association of Group 11 and the solodized-solonetz soils of Group 13.

GROUP 13.—SOLODIZED-SOLONETZ ASSOCIATION.

Gross area 500,000 acres.

The solodized-solonetz soils of this association are fairly uniform and cover extensive areas in the east of the region where they are apparently formed on sediments of the Blythesdale Group. A constant feature of this association is the presence of a bull oak forest with the soils usually occupying flat level sites with some areas of impeded surface drainage. The soils differ from the sandy solodized-solonetz of Group 11 in that they normally have shallower A horizons of sandy loam to clay loam textures. The A horizons are again sharply demarcated from a dense clay B horizon.

The surface of the soils is more compacted than in the sandy solodized-solonetz and is frequently strewn with small ironstone nodules. The A_1 horizon ranges from 3 to 6 inches in thickness, is generally a light shade of greyish brown or brown in colour and with a texture that ranges from sandy loam to clay loam but is more commonly the latter. The A_2 horizon is well developed and usually strongly bleached to a light-grey colour, it ranges from 2 to 4 inches thick and is commonly a clay loam in texture and is rather vesicular and structureless with often moderate amounts of ferruginous nodules.

The B_{21} horizon is sharply demarcated from the A_2 and is a tough dense clay with usually a fairly strong development of columnar or prismatic structure, the diameter of the columns averaging 4 to 5 inches but occasionally greater. The colour of the clay is normally grey-brown with some grey and yellow mottling. Ferruginous nodules are often present. This horizon grades into the B_{22} which has a massive to coarse blocky structure and is somewhat friable with a greyish-brown to yellowish-brown colour. Small amounts of carbonate often occur in this horizon, sometimes in conjunction with minor amounts of ferruginous nodules. The following profiles illustrate typical examples of these solodized-solonetz soils :—

(i.) Profile approximately 10 miles south of Boondandilla Station.

A_1	0– 6 in.	Brown loam to clay loam, compact surface with slightly platy structure, then massive and slightly hard. Surface veneer of small ferruginous nodules and slight amounts through the soil. pH 5·7. Merges into
A_2	6–10 in.	Light-greyish-brown clay loam (bleached), massive but rather vesicular, abundant ferruginous nodules, pH 5·4. Sharply demarcated from
B_{21}	10–18 in.	Grey-brown medium to heavy clay, mottled grey and yellow, columnar to prismatic structure, hard and tough, moderate ferruginous nodules decreasing with depth, pH 6·0. Merges into
B_{22}	18–36 in.	Yellowish-brown medium clay, massive, friable, trace of ferruginous nodules and small amounts of carbonate at lower levels, pH 7·7.

(ii.) Profile at Beebo-Magee road junction south of Inglewood.

A_1	0– 6 in.	Light-greyish brown clay loam, compact surface, rather vesicular, structureless, pH 5·4. Merges into
A_2	6–10 in.	Light-grey to almost white clay loam, vesicular and structureless with some ferruginous nodules and some gravel at the base, pH 6·3. Sharply demarcated from
B_{21}	10–15 in.	Grey-brown heavy clay, somewhat mottled, strong columnar structure with domed columns 4–5 inches in diameter. Hard and tough, pH 6·8. Merges into
B_{22}	15–30 in.	Greyish-brown medium clay, coarse blocky to massive, fairly friable, faint traces of carbonate, pH 7·8. Merges into

BC 30–48 in. Grey-brown medium clay with some orange mottling, massive, firm to hard, trace of gravel, pH 7·4. Grades into

48–54 in. Grey-brown light clay with fairly abundant gravel, mainly waterworn quartz and slate up to 1 inch diameter, pH 6·4.

54–60 in.+ Light-brown gravelly clay with larger waterworn gravel, pH 6·9.

(iii.) Profile 2 miles south of Tara and Crowder Creek road junction, Moonie Highway.

A_1 0– 4 in. Brownish-grey sandy clay loam, massive to slight platy, soft to slightly hard, pH at 2 inches is 5·5. Merges into

A_2 4– 6 in. Light-brownish-grey to grey sandy loam, massive and slightly vesicular, slightly hard. pH at 5 inches is 6·0. Sharply demarcated from

B_{21} 6–14 in. Greyish-brown heavy to medium clay with faint yellowish and black mottling. Tough and dense with columnar structure averaging 10 inches in diameter and columns domed up to 3 inches. pH at 8 inches is 8·0. Merges into

B_{22} 14–30 in. Brown medium clay with orange and grey mottling, coarse blocky to massive, more friable, pH at 15 inches is 7·5, at 24 inches is 8. Merges into

BC 30–60 in. Light-greyish-brown sandy clay, dull brown and grey mottling, friable, pH 8·0 to 8·5. Merges into

60–70 in. Light-greyish-brown sandy clay loam, fairly coarse. Some yellowish mottling and isolated bright red ironstone fragments. Slightly hard. pH 8·0–8·5.

Analytical Data—

The A_1 horizon is usually fairly strongly acid, with reaction values around pH 5·5. The reaction of the A_2 is rather more variable but is always acid with values sometimes lower, sometimes higher than the A_1. The B_{21} horizon ranges from slightly acid to neutral, the B_{22} is normally moderately alkaline. In the deeper subsoils conditions may again become acid. The A_1 horizon is strongly unsaturated but the B_{22} horizon clays are almost fully saturated. Magnesium is the dominant exchangeable metal cation and may range up to 70 per cent. of the total metal ions in the B_{21} horizon. Exchangeable sodium shows a marked rise with depth (up to 7 m. equivs. per cent. or 30 per cent. of the total metal cations in the B horizons). Exchangeable calcium is very low, being greatly subordinate to both magnesium and sodium in the B horizons. Chloride and total soluble salts are low to negligible in the A horizons but may show a slight accumulation in the B horizons (up to 0·06 per cent. NaCl). Total nitrogen is low while available phosphate ranges from low to very low. (Always less than 25 p.p.m. P_2O_5).

Vegetation—

The vegetation of these solodized-solonetz soils is almost invariably an open forest dominated by bull oak (*Casuarina leuhmannii*) with *Callitris glauca, Eucalyptus populnea, E. crebra* and *E. pilligaensis* usually associated.

Minor Associated Soils—

Throughout the mapped area of this association there are small occurrences of the sandy surfaced solod-solodic-solodized-solonetz association which usually may be expected when cypress pine becomes greatly dominant over the bull oak. In addition there are frequently bare rock outcrops of mottled zone lateritic material and lateritised sandstone giving rise to lithosolic soils and some small areas of shallow lateritic red earths. Very occasionally there are isolated occurrences of grey brigalow clays too small to be mapped separately.

Group 14.—Stony Solodized-Solonetz Association.

Gross area 62,000 acres.

This association occupies the area to the south of Inglewood where it is apparently developed on sediments (often lateritised) of the Bundamba Group. The association is almost entirely composed of solodized-solonetz soils of which there are two important groups, both being closely related geographically and approximately equal in area. One group of soils is characterised by a stony surface and a certain amount of gravel throughout the upper levels of the profile while the other group is the clay loam surfaced solodized-solonetz soils described in Group 13. In general, the topography possesses slightly more relief than the Group 13 association with the stony surfaced soils occupying the very low flat ridges and the non-stony soils the lower flat areas between the ridges.

The surface of the stony solodized-solonetz group soils is almost invariably covered with a thin layer (up to an inch thick) of gravel, mainly ironstained quartz and jasper-like siliceous material (Plate 26). Some of this gravel appears waterworn but much of it is still quite angular. This gravel usually only persists down the profile for some 6 inches into the top of the B_{21} horizon although gravel may again reappear below 5 feet. It seems likely that the source of this stony material must be the neighbouring higher areas of old silicified Palaeozoic rocks which occasionally protrude through the later Bundamba sedimentary cover.

The A_1 horizon of these soils is a thin (3 to 4 inches) clay loam frequently packed with gravel. Colour is light-brown or light-reddish-brown. The A_2 horizon is strongly bleached, ashy in colour and ranging from half an inch to 2 inches in thickness depending on the degree of irregularity of the top of the B_{21} horizon. Lesser amounts of gravel are again present with occasional ferruginous nodules. The B_{21} dense clay horizon is sharply defined from the A_2 and usually possesses a well developed columnar structure, the columns having rounded tops some 5 to 6 inches in diameter. Colour is usually brown to reddish brown. Slight amounts of gravel are present in the top of this horizon. The B_{22} horizon has a massive structure, is somewhat more friable and may contain traces of free carbonate. The following profiles illustrate the characteristic features of these soils :—

(i.) Profile 2½ miles south of Inglewood along the Texas road. Low ridge with slight gravel on the surface and a dense vegetation of the shrubs *Acacia ixiophylla* and *Melaleuca nodosa*, together with *Eucalyptus crebra* and *E. pilligaensis*.

A_1	0– 3 in.	Light-reddish-brown clay loam, slight amounts of siliceous gravel, slightly hard. Merges into
A_2	3– 4 in.	Light-reddish-grey-brown clay loam (only faintly bleached), massive, slightly hard. Fairly sharply defined from
B_{21}	4– 15 in.	Light-reddish-brown heavy clay, weak columnar to prismatic structure. Hard and dense. Merges into
B_{22}	15– 30 in.	Reddish-brown medium clay with grey mottling, slightly gritty, massive, less hard ; merges into
BC	30– 36 in. +	Grey clay with some dull red mottling, moderately gritty.

In the vinicity of Brush Creek along the Inglewood road there are small areas of these stony surfaced soils which support a fairly dense ground cover of the spinifex *Triodia irritans*. The following profile is from a flat area near the Beebo road crossing of Brush Creek :—

A_1	0– 3 in.	Light-brown clay loam with much ironstained quartz and jasper gravel. Fairly sharply defined from
A_2	3– 4 in.	Light-grey (strongly bleached) clay loam with lesser and smaller sized gravel and some ferruginous nodules. Sharply defined from

Plate 25.

Profile of a solodized-solonetz soil (Group 13) 16 miles south of Inglewood. A prominent bleached A_2 horizon is present but the columnar structure in the tough clay B horizon is only weakly developed.

Plate 26.

Stony surfaced solodized-solonetz soils near Brush Creek south of Inglewood, here supporting a dense ground cover of spinifex.

B_{21}	4– 10 in.	Brown heavy clay with slight gravel in the upper 2 inches. Strong columnar structure with columns 5–6 inches in diameter. Hard and tough, very dense, numerous spinifex roots ; merges into
B_{22}	10– 48 in.	Brown medium clay with slight dull orange mottling, massive, firm to hard ; grades into
BC	48– 60 in.	Greyish-brown sandy clay with grey and yellowish mottling and some black stainings. Hard.
	60– 62 in. +	As above but with fairly heavy amounts of slightly rounded quartz and jasper gravel.

Analytical Data—

An analysis of the Brush Creek profile shows a medium acid A_1 horizon, a neutral A_2, and the B_2 horizons moderately alkaline becoming more strongly so with depth. The B horizon clays show a high degree of saturation with magnesium the dominant exchangeable metal cation, constituting up to 70 per cent. of the total exchangeable metal ions. Exchangeable sodium is high throughout, increasing up to 30 per cent. of the total exchangeable metal ions in the B_2 horizons. Exchangeable calcium is extremely low in the B horizons. The total soluble salt and chloride contents are fairly low throughout but show slight accumulation in the B horizons. Total nitrogen and organic carbon are low in the A horizons with available phosphate also low.

Vegetation.—

The vegetation of the stony surfaced soils is an open forest dominated by *Eucalyptus crebra, E. pilligaensis,* and *E. populnea* with lesser *Casuarina leuhmannii.* There is frequently a dense shrub layer of *Acacia ixiophylla* and *Melaleuca nodosa.*

The other group of solodized-solonetz soils which also occupy a prominent part of this association again support a forest dominated by *Casuarina leuhmannii* as in Group 13.

Minor Associated Soils.—

Very limited areas of other soils occur in the association. Along some of the sandy water-courses there are small developments of sandy surfaced solod-solodic-solodized-solonetz soils while there are also a few small areas of shallow lithosolic soils developed on sandstone and lateritic outcrops and occasional small inliers of Palaeozoic rocks.

(*i*) SOLONETZ SOILS.

As Kelley (1951) has pointed out in his review of alkali soils the Russian term solonetz has not always been used in exactly the same sense. In his early work on alkali soils Gedrioz' (1912) usage of solonetz was in the sense of a soil containing excessive exchangeable sodium. However, later both he and other Russian workers referred to solonetz as a leached alkali soil, the sub-horizons of which contained more or less exchangeable sodium and the profile of which showed a certain peculiar morphology while there is an absence of, or only low concentration of, salts except at considerable depth. In more recent years many of the soils which would have earlier been designated as solonetz have been called solodized-solonetz but again there has not always been uniformity of usage, some authors placing the emphasis on morphology and others on the chemistry of the soils. Thus in Australia Stephens (1953) has placed emphasis almost entirely on morphology while Hallsworth *et al* (1953) have, in addition, stressed the chemical features. As it would seem that in the solonetz, solodized-solonetz and solod group of soils a satisfactory distinction cannot be drawn on the basis of morphology alone, in this present study the diagnostic features of a solonetz soil are taken to be those indicated by Hallsworth *et al* (1953). Thus the solonetz profiles are alkaline throughout, strongly so in the subsoils which contain much exchangeable sodium. The B horizon displays well developed columnar structure and may or may not be capped by a bleached A_2 horizon.

Plate 27.
The Yelarbon "desert" showing erosion of the A horizon and also part of the B, the soil material has been removed mainly by wind but partly by water.

Plate 28.
The top of the B horizon of the highly alkaline solonetz soils of the Yelarbon "desert" exposed by erosion and showing the well developed irregular columnar structure. The columns are only slightly domed.

Group 15.—Solonetz–Solodized–Solonetz Association.

Gross area 17,000 acres.

The so-called Yelarbon " desert " which surrounds the township of that name is an area of alkaline soils which supports an unusual improverished and stunted vegetation. Much of the area has a claypan-like appearance due to removal by erosion of the surface soil horizons. Most of the desert area proper consists of solonetz soils which are highly alkaline but towards the margins less alkaline typical solodized-solonetz soils occur giving conditions that are more favourable for the growth of normal vegetation.

The solonetz soils normally have a fairly thin A_1 horizon (up to 4 inches) but this thickness may be increased by accession of wind eroded material in some places, especially where spinifex clumps exert a binding effect, while in other areas being entirely removed. This A_1 horizon is usually an almost structureless fairly soft light-greyish-brown clay loam which is readily eroded by wind and water if the normally sparse grass cover is disturbed. An A_2 horizon may be present but if so is only slightly bleached. Sometimes the A_1 horizon may give a very slight effervesence with acid, indicating a faint trace of free carbonate.

The B horizons are fairly sharply defined from the A but although they are a medium clay in texture the consistence is not as hard and tough as in the solodized-solonetz soils. The brownish B horizons have extremely low permeability to water, apparently because of the highly dispersed nature of the sodium clay. Even after prolonged steady rainfall there is very little penetration of water below the A horizon. Where the A horizon has been removed by erosion even the upper part of the B may be eroded by wind and water as such an exposed B horizon will not support any protective vegetation. Such an effect is shown in Plate 27. The B_{21} horizon often displays a coarse prismatic to columnar structure, the columns ranging from 6 to 18 inches in diameter and usually possessing a gently domed upper surface. Where the A horizon has been removed by erosion these columns may be seen on the exposed surface (Plate 28) The B_{21} horizon with columnar structure merges gradually into the B_{22} which is massive, rather more friable, and contains numerous black fleckings, some of which are possibly organic stainings. The deeper horizons are a brown to greyish-brown friable clay which becomes sandy with depth. Free carbonate is present in the B horizons and increases with depth, becoming prominent in the form of fairly large nodules. It appears from tests that some of this material is sodium carbonate. The following profiles illustrate the features of this solonetz soil :—

(i.) Profile 3 miles south of Yelarbon along the Keetah road.

A_1	0– 3 in.	Light-greyish-brown clay loam, fairly soft and massive, slightly bleached at the base (incipient A_2), fairly sharply defined from
B_{21}	3– 10 in.	Brown medium clay, moderately coarse prismatic structure, fairly hard, merges into
B_{22}	10– 24 in.	Light-brown medium clay, angular blocky to massive, fairly friable, trace of carbonate, merges into
BC	24– 36 in.	Yellowish-brown light clay, friable, slight amounts of carbonate.

(ii.) Profile approximately 3 miles south-east of Yelarbon.

A_1	0– 4 in.	Light-brownish-grey clay loam, slightly platy on the surface then massive and rather vesicular, slightly hard, fairly well defined from
A_2	4– 10 in.	Light-brown clay loam, massive but finely vesicular and fairly hard, not a very sharp break to

B_{21}	10– 18 in.	Brown medium clay with slight grey mottling and numerous black fleckings. Fairly coarse columnar to prismatic structure with diameter of columns 6 to 18 inches. Still slightly vesicular, hard with a trace of carbonate. Merges into
B_{22}	18– 36 in.	Light-brown medium clay, massive but more friable, some carbonate nodules. Merges into
BC	36– 60 in.	Light-greyish-brown clay, slightly sandy at depth, fairly friable with some carbonate nodules. Merges into
	60– 72 in.	Pale-greyish-brown sandy clay, massive and rather vesicular with black stainings and some fairly large carbonate nodules but little or no fine earth effervesence. Merges into
	72–108 in.	Pale-greyish-brown sandy clay loam to loam with some soft carbonate patches, merges into
	108–132 in.	Light-grey to very pale-brownish-grey loamy sand, rather cemented. Mass appears very vesicular but is difficult to wet. Merges into
	132–162 in.	Light-grey to very pale-brownish-grey sand, loose and uncemented, merges into
	162–192 in.	Light-brown slightly coarser sand, fairly loose and soft.

Analytical Data—

An analysis of the above profile shows a moderately alkaline A_1 horizon and the remainder of the profile very strongly alkaline (pH 10·0 or slightly higher below 10 inches and continuing with depth). In the A_1 horizon magnesium is the dominant exchangeable metal cation with calcium subdominant and sodium also significant. In the A_2 horizon sodium shows a fairly sharp rise while calcium and magnesium remain more or less constant. In the B_2 horizons both calcium and sodium show a very marked rise with the exchangeable sodium rising to 18 m. equivs. per cent. (46 per cent. of the total exchangeable metal cations) in the B_{22} horizon. Magnesium does not show an appreciable increase in the B horizons and is subordinate to both sodium and calcium. Exchangeable potassium is present in normal amounts throughout. In the B horizons a soil water extract yielded up to 3 m. equivs. per cent. of sodium, some of which may be due to free sodium carbonate. Chloride and total soluble salt contents show an increase to a maxium in the B_{22} horizon but values are not unduly high (0·07 per cent. NaCl), although higher than in the typical solodized-solonetz profiles of Group 13. Available phosphate is low in the A horizons but rather strangely shows a very marked increase in the B_2 and lower horizons.

These highly alkaline solonetz soils do not occupy the entire mapped area of this association. Towards the margins there is a zone of solodized-solonetz soils developed which support a more normal vegetation. These soils are rather similar to those described in Group 13. They have a very thin A_1 horizon (seldom exceeding 4 inches) and usually a bleached A_2 which may be strongly developed. The B horizon is a very tough dense clay which frequently displays columnar or prismatic structure. This soil is again susceptible to wind erosion (mainly through lack of protective vegetation) but not to the same extent as the solonetz soils. The following profiles are characteristic :—

(i.) Profile ¾ mile north of Yelarbon.

A_1	0– 2 in.	Grey loam, compact and slightly hard, merges into
A_2	2– 4 in.	Light-grey sandy clay loam, strongly bleached, massive and fairly hard, sharply defined from
B_{21}	4– 8 in.	Grey-brown heavy clay to sandy clay with light grey mottling. Very hard and tough with some degree of columnar to prismatic structure. Merges into

B_{22}	8– 24 in.	Grey-brown sandy clay, coarse blocky to massive, more friable, merges into
BC	24– 36 in.	Grey-brown clay, slightly gritty with some orange mottling. Friable with free carbonate increasing with depth.

(ii.) Profile of marginal desert 1 mile south-west of Yelarbon along Kurumbul road.

A_1	0– 3 in.	Grey clay loam, massive and slightly porous, fairly soft, numerous black flecks, sharply defined from
B_{21}	3– 14 in.	Grey-brown heavy clay, tough and dense, coarse blocky to massive, trace of carbonate, merges into
B_{22}	14– 48 in.	Brown medium clay, slight greyish mottling, massive, fairly hard, some black stainings.
BC	48– 70 in.	Greyish-brown medium clay, slightly sandy with some dull orange mottling.

Analyses of these solodized-solonetz soils show that they have slightly acid to neutral A horizons while the B horizons are only moderately alkaline. The Kurumbul road profile becomes strongly acid with depth after rising to pH 8·2 in the upper part of the B_{22} horizon. In this it shows similarity with the neighbouring weakly solonised belah soils, discussed in Group 6. The exchangeable metal cations of these marginal desert soils are dominated by magnesium. Although sodium is still high it does not reach the levels obtained in the solonetz profiles. Chloride and total soluble salt contents are lower in the A horizon than in the solonetz but chloride reaches higher levels in the B_{22} and deeper horizons.

It would appear then that these marginal solodized-solonetz soils could represent a stage in the desalinisation of the solonetz soils ; some exchangeable sodium has been removed from the exchange complex and soluble salts have been washed further down the profile. On the other hand field evidence shows that the solonetz soils are not being leached to any extent under present conditions so that it may be that these marginal soils simply did not originally contain excessive amounts of sodium salts. It is doubtful whether the solonetz true " desert " soils are being desalinised to any extent at present by natural leaching. As earlier pointed out in the account of the geology of the region the Yelarbon area is apparently underlain at shallow depths by a series of water-bearing gravel and sand beds and well records indicate a very marked fluctuation in this perched water table. After periods of heavy rains it may rise almost to the surface and is apparently never much deeper than 40 feet below the surface. Analyses of this water show a high content of sodium bicarbonate (some 12 m. equiv./litre) so that it would appear that this fluctuating water table furnishes a most likely explanation for the highly alkaline nature of the solonetz soils.

Vegetation—

The solonetz and solodized-solonetz soils of this association support a somewhat unusual stunted vegetation (in which the spinifex *Triodia irritans* is prominent) which has resulted from the chemical and physical characteristics of the soil. This has been described in more detail in the section on the vegetation of the region.

(*j*) LITHOSOLS.

The soils herein designated as lithosols are characterised generally by possessing only a shallow stony solum with a weak degree of profile development. Bare rock outcrops are frequent. Two associations have been differentiated on the basis of parent material.

Group 16.—Lithosols Derived from Sandstone and Lateritic Material.

Gross area 291,000 acres.

Shallow stony soils are developed on various areas throughout the outcrop zone of the Blythesdale Group and elsewhere throughout the region where mottled zone lateritic residuals occur. The solum is invariably thin with much partly decomposed rock present. Where the parent material is a more normal sandstone the soils are light coloured and coarse textured; where the solum exceeds 12 inches in depth there is a tendency for a podzolic or solodic morphology to develop. However, usually these soils are less than 12 inches thick with bare sandstone outcrops frequent. Where the parent rocks have been affected by lateritic influences (and this is common) the soil invariably has a reddish colour which is sometimes intense.

The shallow soils developed on the mottled zone of the laterite profile frequently have a thin surface veneer of small ironstone nodules and a loam or clay loam texture. Colour varies from brownish red to red depending on the concentration of ferruginous material in the mottled zone parent material. In many areas there are completely bare outcrops of the mottled zone especially near escarpment margins, but where these gradually slope away as in the cuesta-like residuals deeper profiles develop which may have the characteristics of lateritic red earths, red-brown earths or solodized-solonetz.

An open forest formation is usually developed on these lithosolic soils, the chief species being *Eucalyptus melanophloia, E. crebra, E. populnea* and *Callitris glauca.* In some areas low wattle " scrubs " are prominent, *Acacia cunninghamii* being the chief species.

Group 17.—Lithosols Derived from Palaeozoic Rocks.

Gross area 4,000 acres.

Palaeozoic rocks are present in small areas only in the extreme south-east of the region where they give rise to a hilly maturely dissected landscape. The cherty sediments and silicified mudstones which are steeply dipping with a prominent cleavage do not weather readily except to small angular fragments so that not only are the soil profiles very shallow but they also contain much angular siliceous material. The texture of such soil as is formed is usually a clay loam or sandy loam with a light-brownish colour.

The vegetation of these stony soils is quite characteristic, being an open forest dominated by *Eucalyptus dealbata, E. crebra, E. melanophloia* and some *Callitris glauca.*

VII.—SUITABILITY OF THE SOILS FOR AGRICULTURE.

In an earlier chapter various climatic factors of considerable importance to agriculture have been discussed. In this section discussion will be confined to those aspects of the soils which influence their agricultural utilisation but in certain instances some soil properties assume a particular importance because of existing climatic circumstances.

It may be seen from the map showing the extent of cultivated land that the degree of agricultural development that has taken place in the region is rather limited, and of this a considerable portion has been devoted to the production under irrigation of a rather specialised crop (tobacco) in the southern part of the region along Macintyre Brook and the Dumaresq River. Consequently there is not a wide range of agricultural experience available and thus the estimation of suitability of the various soils for agriculture is largely inductive.

In attempting to assess the potential of a particular soil for crop production two aspects have to be considered. (In the main only dry land agriculture will be discussed). Thus it is important to distinguish between the nutrient status of a soil, which can be assessed chemically on the basis of whether it contains the necessary plant nutrients in an available form, and the productivity of a soil which may be governed by a number of factors apart from chemical properties. In the assessment of productivity various physical properties are often very important. A summary of the major factors that may influence crop production on the various soil units is presented in Table 13, some of these factors are of sufficient importance to warrant further comment.

1.—Chemical Factors.

(*a*) Soil Reaction.

The availability of many plant nutrients is to a large extent dependent on soil reaction. Thus under conditions of strong acidity certain essential elements may not be present in a form available to plants. In particular phosphorus, calcium and potassium are major plant nutrients that become less readily available with increasing acidity, while nitrogen fixation by legumes and transformation of organic nitrogen to forms available to plants also becomes increasingly less favourable. With regard to the more important trace elements the availability of molybdenum is inhibited by strongly acid conditions.

Certain soils described from the region are characterised by undesirably acid profiles. Those with acid A horizons usually have an associated low calcium status and it is evident that such soils would need liming before they could be successfully utilised for agriculture or pasture improvement. Many of the gilgaied grey clays, although neutral or slightly alkaline at the surface, rapidly drop to a pH value as low as 4·5 at a depth of 12 inches. These soils are somewhat anomalous and it is difficult to give a generalised prediction of their possible cropping behaviour. However this problem will only be encountered in certain parts of the region, more particularly in the northern (Tara-Glenmorgan) section.

(b) Exchangeable Metal Cations.

Several of the soil groups are characterised by undesirably high amounts of magnesium and sodium together with a low calcium status. In particular this applies to the solodized-solonetz, solodic and solod soils but also, although to a lesser degree, to some other soils, particularly in the subsoil horizons. This characteristic is probably most important because of the undesirable physical condition which it induces but it also may be of importance because of an actual calcium deficiency in certain soils. Stout (1949) when discussing the levels of exchangeable calcium required for plant growth, suggested that nutritional disturbances are likely to be encountered when the exchangeable calcium is in the vicinity of 30 per cent. of the exchange capacity. Using this criterion analyses indicate that the sandy surfaced solodized-solonetz, solodic and solod soils, as well as some of the clay loam surfaced solodized-solonetz bull oak soils would be strongly calcium deficient. This same group of soils, together with the deep sands, also has rather low potassium levels and responses would be expected in most cases to additions of potash.

(c) Organic Carbon and Total Nitrogen.

As a whole the soils are uniformly low in organic carbon and total nitrogen, the exceptions being the thin A_1 horizons of some soils and the clay soils developed from Cretaceous sedimentary rocks (Group 3). These generally low values, often associated with narrow C/N ratios, will assume importance following the initiation of any cropping programme. Thus attention will need to be directed at building up the organic matter and nitrogen status of the soils, in many cases this may be accomplished by appropriate farming techniques.

(d) Phosphoric Acid.

Phosphate levels in the great majority of samples have been determined by the " available " phosphate method of Kerr and von Stieglitz (1938) but on several soils total phosphoric acid (hydrochloric acid extract) was determined. In these instances there appeared to be a fairly good general correlation between the total and " available " P_2O_5 values.

It is a striking feature that the greater proportion of the soils examined are low and in many cases very low in available phosphate. The chief exceptions are the more recent alluvial soils of Group 1 which have the highest phosphate levels of all, the clay soils derived from Cretaceous sediments (Group 3), the red-brown earths (Group 8) and some of the heavy grey clays of Group 2. In addition the thin A_1 horizons (2 to 4 inches) of the belah soils (Group 6) may have a reasonably good phosphate status. The remainder of the soils are generally characterised by a low to very low available phosphate status. (Normally less than 50 p.p.m. P_2O_5 and frequently less than 25 p.p.m.).

This generally low phosphate status is worthy of further comment. The soils showing low values may be grouped into two broad categories. In the strongly solonised (and solodized) groups such as 7, 11, 12, 13, 14, and 15 past experience with similiar soils is such that this is not surprising. The same comment would hold for the lateritic red earths (Group 9). In the second and most important category are the clay soils supporting a dense vegetation of brigalow (Groups 4 and 5) which occupy 1·8 million acres or one-third of the total area surveyed. Elsewhere in Queensland clay soils supporting a vegetation of brigalow have been characterised by a rather variable phosphate status but this would appear to be the first instance in which so large and uniform an area has been characterised by such a generally low phosphate status. The reasons for this are probably several. Firstly, there has been little extensive investigations of these soils in Queensland and, secondly, it has to be realised that there is rather a wide diversity of clay soils supporting a vegetation of brigalow throughout the State. Those described from this region differ in many aspects from certain other clay soils in Queensland which have a brigalow dominant vegetation, the particular and most important features being their probable genetic history. This will be elaborated later but it might be mentioned here that it appears that these Group 4 and 5 soils are in many cases extremely old and have had a history that probably involved at one stage conditions of very high leaching. In these circumstances then it might not be so surprising that their phosphate status is rather low. In order to give a better indication of the phosphate levels that obtain in these soils a frequency distribution table (Table 11) has been drawn up for those samples that have been analysed.

TABLE 11.

FREQUENCY DISTRIBUTION OF "AVAILABLE" P_2O_5 IN STRONGLY GILGAIED CLAY SOILS SUPPORTING A BRIGALOW DOMINANT VEGETATION.

p.p.m. available P_2O_5	< 20	20–30	30–40	40–50	50–60	60–100	> 100	Total Samples
0– 6 in. ..	2	2	2	5	..	2	1	14
0–12 in. ..	2	3	1	..	..	..	1	7
6–12 in. ..	1	1	5	1	3	1	..	12
12–24 in. ..	6	3	1	..	..	1	..	11

(It has been accepted to date that less than 50 p.p.m. represents a low phosphate status and that a response to fertilisation would be expected for soils with values less than 40 p.p.m.)

Of the 20 profiles examined 15 were puff sites and 5 depressions. Both the values greater than 100 p.p.m. occurred in depression profiles. The greater number of puff profiles were selected due to the difficulty of obtaining a depression sample free of ashes, organic matter, &c., washed in from the puff.

A further interesting feature is that the available phosphate figures appear to be quite independent of soil reaction. A profile showing a pH drop from 7·2 at the surface to 4·6 at 12 inches showed little or no change in available phosphate over this range.

An anomalous feature associated with this apparently low to very low phosphate status on these soils is due to the fact that some of these clays (often acid at shallow depths) have been cultivated and are growing satisfactory cereal crops without the necessity for phosphatic fertilizers. In the light of the data presented above it is difficult not to expect these crops to show a marked response to superphosphate although it is interesting to note the observation of Birch (1951) that phosphate responses are not to be expected on acid soils where the base saturation exceeds 80 per cent. The acid clays that often occur at very shallow depths beneath the brigalow soils are usually some 70 per cent. saturated. It is proposed to carry out further investigations with regard to the phosphate status of this group of soils.

The soils supporting a belah dominant vegetation (Unit 6) have a better phosphate status in their A horizons but again subsoil values are very low. This is shown in the frequency distribution table below (Table 12).

TABLE 12.

FREQUENCY DISTRIBUTION OF "AVAILABLE" P_2O_5 IN SOILS SUPPORTING A BELAH DOMINANT VEGETATION.

p.p.m. available P_2O_5.	< 20	20–30	30–40	40–50	50–60	60–100	Total Samples.
A horizon (to 3 or 4 in.)	..	..	2	1	2	4	9
B_{21} horizon (to 12 or 15 in.)	4	3	..	2	..	..	9
B_{22} horizon (to 24 or 30 in.)	3	1	1	1	1	..	7

2.—Physical Factors.

It is widely recognised that in assessing the suitability of a soil for agriculture various physical factors are of importance. Stirk (1954) has proposed an index for rating the physical status of soils and while it is not proposed to apply this scheme in the present study certain factors are worthy of some comment.

(a) SOIL TEXTURE AND MOISTURE RELATIONSHIPS.

Soil texture is of importance not only because of its relation to ease of land preparation but also by virtue of the prevailing climatic regime. Broadly the coarser textured soils are more favoured from the cultivation point of view but this is usually offset by the normally more favourable water retaining capacities of the finer textured soils. In the region concerned, characterised as it is by a somewhat unreliable rainfall, this latter factor assumes major importance. Thus in general cereal crops (more particularly winter cereals) cannot be successfully grown unless soil moisture is conserved by means of a fallow. Therefore to a large extent successful dry land agriculture is dependent on soils of adequate moisture holding capacity, normally the clay and clay loam soils.

Limited determinations have shown that the majority of the clay soils have an adequate range of available mositure although the amounts actually available for plants may be somewhat less than the determined values as many of the clay soils have appreciable salt contents, which would increase the osmotic pressure of the soil solution. Another feature associated with the clay soils is that they normally have high wilting points, consequently light falls of rain may not be effective in providing moisture for plant growth. A further adverse feature of some of the clay soils is that they possess only a rather narrow range of moisture conditions during which they can be cultivated, the soils either being too dry and hard or too wet and sticky for efficient land preparation. This feature is probably aggravated where a high exchangeable sodium status obtains in the clays, this is so particularly in the brigalow soils (Groups 4 and 5).

(b) Structural Stability and Porosity.

These two factors are interrelated to some extent and both have an important bearing on certain of the soils in the region. It is well known that surface soils of unstable structure suffer deleterious effects from continued cultivation. This may lead to water and root penetration difficulties and a lack of aeration in the root zone. Certain soils in the region possess this characteristic to a rather marked degree, in particular the clay loam surfaced soils of Groups 7 and 13 show a marked structural break down following cultivation and consequently after rain they tend to run together and puddle, and then set hard on drying. This effect markedly reduces the efficiency of rainfall absorption.

Porosity problems arise not only as described above but in addition many of the subsoils are rather impermeable in their natural state. In particular this applies to soil groups 7 and 13 but also the problem is present to a certain extent in some other soils. The sandy surfaced solods, solodic and solodized-solonetz soils of Groups 11 and 12 have dense impermeable subsoils while conditions may also be somewhat unfavourable in some of the clay soils, such as Groups 2, 4, and 5. However, in the case of the clay soil profiles the overall water penetration is so slow that waterlogged conditions should not arise if surface drainage is adequate. Initial water penetration into the clay soils is rapid, due chiefly to the deep cracks that develop on drying. However, following saturation of the surface soil, water penetration falls off rapidly. Thus the incidence and intensity of the rainfall is often an important factor in the degree of water penetration in these soils.

(c) The General Nature of the Soil Surface.

This is a rather broad aspect as in its widest sense landscape features are involved, with the attendant concerns of erosion susceptibility and the excessiveness or otherwise of surface drainage. As the region concerned is largely characterised by flat lands or very gentle slopes it is intended to comment only on those features of soil microrelief which may be of importance in any agricultural development.

Many of the soils possess minor surface undulations that are the manifestation of a slight gilgai process. However in Groups 4 and 5 (the brigalow soils) a strong to extreme gilgai microrelief is frequently developed. This very uneven surface condition renders efficient land cultivation extremely difficult and is one of the main disadvantages to the agricultural utilisation of these particular soils. A further problem arises in that experience has shown that even if these soils are levelled the gilgai microrelief will reappear after a period of years if regular cultivation is discontinued. Thus the virtual absence of any but a very slight microrelief in the belah soils (Group 6) makes them a much more attractive agricultural proposition. However one point may be made in favour of the strongly gilgaied soils. They occupy topographically almost level sites and thus there is little rainfall loss through run-off, any excess water from puff or level sites being collected in the depressions.

TABLE 13.

Factors Influencing Arability of the Soil Units.

Soil Unit.	Area (1.000 acres).	Chemical Factors.	Physical Factors.	General Remarks.
1. Recent Alluvial Soils ..	112	Fertility status generally good. On the sub-mature red-brown earths there is a possibility of undersirable chloride accumulation with irrigation	Normally attractive physically although the clay loam surfaced soils show a tendency to set following cultivation and irrigation. Generally well drained	Suitable for a fairly wide range of crops with irrigation. Most areas can be inundated by exceptional floods
2. Grey soils of heavy texture	373	Fertility moderate to fair, phosphate may be somewhat low. Chloride and salt content often rather high	High wilting point heavy clays that may give some difficulty in preparation. Surface drainage often poor, internal drainage very slow when wet. Very flat except for occasional slight microrelief	Most areas subject to regular flooding in summer and occasionally winter. Otherwise should successfully grow cereal crops
3. Grey and brown soils of heavy texture	109	Fertility fair to good, phosphate may be slightly low in some grey clays	Soils normally well drained except in valley floors. Slight linear gilgai present on some slopes. Soils on crests of some ridges may be somewhat shallow	Rather undulating landscape with some moderate slopes. Soils generally well suited for cereal crops, erosion hazard present on some slopes
4. Grey and brown clays (Brigalow soils)	1,586	Fertility status rather variable. Fair to moderate except where acid at surface or very shallow depths. Phosphate appears to be uniformly low to very low in most areas. Salt content may be fairly high	Chief disadvantage is the frequent strongly developed gilgai microrelief. Both surface and internal drainage normally poor. Clays are dense with fair range of available moisture but wilting points are fairly high	Usually flat topography with few natural drainage lines. Normally a dense timber cover. Many areas suitable for cereal crops where land can be successfully prepared
5. Ditto	226			
6. Weakly solonised brown clay loams (Belah soils)	984	Fertility fair to good although phosphate status of subsoil may be low. Subsoil salt may be moderate to fairly high	Surface soil horizons slightly unstable otherwise soils are physically attractive. Structure of subsoil clay is good. External and internal drainage fairly good. Occasional slight gilgai microrelief. Subsoils have fair range of available moisture	Normally flat topography with a dense forest vegetation. Generally suitable for cereal crops
7. Weakly solodized-solonetz soils (Sandalwood and Box vegetation)	471	Fertility only moderate, phosphate normally low in subsoils. Some subsoil salt accumulation	The clay loam surface soils are poorly structured with a narrow range of available moisture. Clay subsoils are dense and relatively impermeable and thus internal drainage is poor. May be a slight gilgai microrelief	Flat topography. Areas often small and scattered and in vicinity of drainage lines. Not generally recommended for agriculture

TABLE 13—*continued.*

FACTORS INFLUENCING ARABILITY OF THE SOIL UNITS.

Soil Unit.	Area (1.000 acres).	Chemical Factors.	Physical Factors.	General Remarks.
8. Red-brown earths ..	114	Fertility status generally fair to good although subsoil phosphate level may be low	Soils attractive physically although there is only a rather narrow range of available moisture in A horizons. Drainage fairly good	Generally flat topography but areas are rather limited. Suitable for cereal crops
9. Lateritic Red earths ..	232	Generally low fertility with extensive fertilizer requirements	Normally attractive physically except where a hard pan exists. Rather low range of available moisture. Usually freely drained	Soils may often be shallow with rock outcrops and moderate slopes. Cannot generally be recommended for agricultural crops
10. Deep sands	19	Generally low fertility	Deep excessively permeable sands, often slightly elevated	Very limited in extent. Only possible agricultural utilisation would be by local irrigation of such crops as citrus and possibly tobacco
11 Sandy solod-solodic and solodized-solonetz soils	296	Very low fertility, surface usually undesirably acid. Subsoils contain undesirably high contents of magnesium and sodium	Very sandy surface overlying dense impermeable clay. Liable to temporary waterlogging as internal drainage is badly impeded	Flat or with gentle to moderate slopes. Undesirable agricultural soils
12. Ditto	25			
13 Solodized-solonetz (Bull oak vegetation)	500	Low to very low fertility. Subsoils contain undesirably high contents of magnesium and sodium	Poorly structured clay loam surface overlying dense impermeable clays. Impeded internal drainage and thus liable to waterlogging. Group 14 soils have a stony surface	Extensive occurrences normally in flat situations. May be some sandstone outcrops. Undesirable agricultural soils
14. Ditto	62			
15. Solonetz-Solodized-Solonetz. (Yelarbon "Desert")	17	Highly alkaline soils with undesirably high amounts of sodium and magnesium. Free sodium carbonate may be present in the profile	A horizon of undesirable physical nature, very susceptible to wind erosion. Subsoils extremely impermeable. Ground water level (salty) may rise close to the surface	Only limited area but nature of soil is prohibitive of almost any crop growth
16 Lithosolic Soils ..	291	Probable low fertility	Normally shallow and stony with frequent rock outcrops	May be moderate to steep slopes. Cannot be considered for agriculture
17. Ditto	4			

Plate 29.

Excavated earth tank in belah country 14 miles south of Meandarra. Much of the region contains little surface water and earth tanks are essential for stock and domestic supplies.

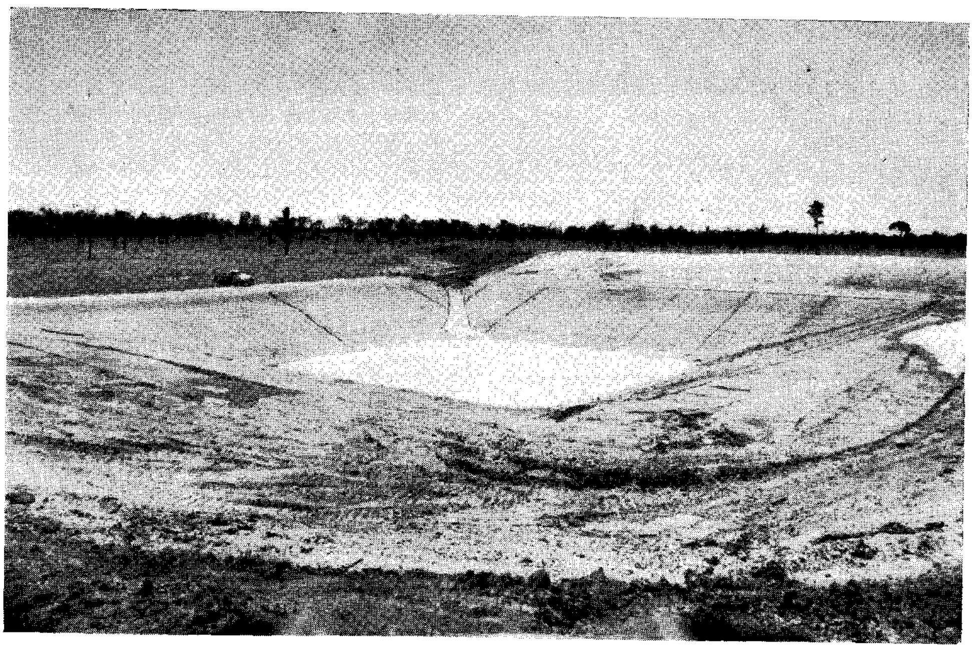

Plate 30.

Large excavated earth tank on Lienassie Holding. This tank is 21 feet 6 inches deep with an excavation of 16,000 cubic yards. However the earth wings enable water to be stored to a depth of 10 feet above the level of the ground surface at the site of the tank.

[Lands Department photo.]

VIII.—PEDOLOGY.

1.—Factors Affecting the Origin and Occurrence of the Various Soil Groups.

A discussion of the factors responsible for the origin and occurrence of the various soils may best be made according to the following subdivision :—

(*a*) Halomorphic influences.

(*b*) Influence of topography and drainage.

(*c*) Influence of parent material.

(*d*) Geomorphic influences and the role of past lateritisation.

(*a*) Halomorphic Influences.

It is a striking feature that nearly every soil group in the region shows evidence of having been subjected at some time or other to halomorphic influences. Almost all of the more impermeable clay soils still contain considerable amounts of soluble salts, often to considerable depths in the profile. Chloride (expressed as NaCl) normally accounts for about half of the total soluble salt content and values of up to 0·5 per cent. NaCl commonly occur in the lower levels of many of the clay soils of the region. In addition many of these clay soils contain appreciable amounts of the sodium ion on the exchange complex, frequently ranging up to 20 per cent. of the total exchangeable metal ions.

In most other soils of the region salt contents are lower but both chemical and morphological evidence indicates that the soils have been solonised, and often solodized, to varying degrees so that frequently the characteristic morphological features of the solodized-solonetz have been formed. Such profiles are characterised by a marked A-B horizon textural differentiation, a rise in pH values with depth and by the dominance of sodium and magnesium in exchangeable cations of the B horizon. This sodium-magnesium dominance in the B horizons of those soils showing a strongly differentiated profile is a noteworthy feature of the region as a whole and is in keeping with the conditions obtaining in a great many Australian soils in which the B horizon clays contain a preponderance of magnesium.

It is evident then that a halomorphic influence has been operating throughout the area surveyed and there are two possible sources for the salts now present in the soils or for the past existence of salts which have caused solonisation. Thus the salt may have been derived either from the normal weathering processes that have affected the soil parent materials or they are of atmospheric origin. A great many of the soils are derived from alluvial parent materials which were probably not inherently salty, or at least there is no evidence to indicate that they were, while those soil parent materials such as the Blythesdale sediments or Tertiary formations have been affected by lateritisation and might logically be expected to have been salt free. It would seem likely therefore that the greater part of the salt has originated through atmospheric accessions.

It is now generally conceded that accessions of cylic salt were received over at least subcoastal Australia in late Pleistocene or early Recent times but with regard to areas further inland it is more difficult to visualise salt accessions of maritime origin. It would seem more likely that such salt accessions originated from the dry interior of the continent where saline lakes and salt pans are abundant even during the present climatic regime. These ideas concerning the origin of the salt have already been postulated in a forthcoming publication. (Hubble and Isbell 1958.)

In the section on the climatology of the region it was pointed out that the present day leaching potential of the climate of the region is probably rather low and it is doubtful if much salt, if any, is now being removed from the soils. The degree of solodization of many of the soils therefore might presuppose a pre-existing climate with a much higher leaching potential that succeeded a more arid period in which the salts accumulated. However the degree of solonisation and solodization of many of the soils is also dependent on certain other factors, the chief of which would appear to be the calcium status of the original soil, together with its clay content and permeability. This has been more fully discussed by Downes (1954) for south-eastern Australia and many of his concepts are applicable to the soils of the present region. Thus there is a clear gradation from the weakly solonised clay loams (Group 6) which have a fairly high calcium status although showing some effects of solonisation and solodization, through the weakly solodized-solonetz soils (Group 7) with a lesser calcium status and a greater degree of solodization, the more typical solodized-solonetz soils (Group 13) with an often low calcium status and a typical solodized-solonetz morphology, to finally the solodic and solod soils which have a very low calcium status and an extremely high degree of magnesium, sodium or hydrogen ion saturation. The solods are considered to represent the end point in the process of solodization. Concomitantly throughout this range there is a decrease in the amounts of salt present in the soil.

(*b*) Influence of Topography and Drainage.

Although the region as a whole possesses little major relief the influence of minor topographic variations and the consequent effect on drainage has played a prominent role in the occurrence and distribution of certain soils. This is perhaps best illustrated by the distribution pattern of the constituent soils of the grey and brown soil of heavy texture association (Group 3). In this association, which is formed on an undulating topography, the brown soils are almost entirely confined to the higher better drained portions of the landscape and never occur in situations where there is any restriction of surface drainage, such as occurs in the lower and flatter sites.

Drainage conditions have also been responsible for the occurrence of localised areas of solodized-solonetzic types within areas of other soil groups. Quite commonly throughout the region where local conditions of restricted surface drainage occur, soils with a characteristic solodized-solonetz morphology are found. As a particular example the red-brown earth group may be cited. Wherever surface ponding occurs the soils develop a bleached A_2 horizon and a tougher prismatic structured B horizon. This morphology is of course partly due to the chemical effects of solonisation but it is only under conditions of intermittent wetting and drying of the profile accentuated by the restricted drainage that the full expression of the solodized-solonetz morphology is developed.

(*c*) Influence of Parent Material.

The role of parent material in soil formation in this region is an important one but is often rather difficult to evaluate as many of the soils have formed on unconsolidated materials, the nature and origin of which are often in doubt. Soils formed in situ from consolidated rocks leave no doubt as to the influence of the parent material on their genesis. The clay soils formed on the calcareous marine Cretaceous sediments, the latosolic soils formed on lateritic materials and the shallow stony soils formed on the Palaeozoic rocks all directly reflect the nature of their parent material in spite of the impress of other soil forming factors.

However, where diverse soils have formed from unconsolidated materials or from the more uniform sediments of the Blythesdale Group the influence of parent material may not be so evident, or at least it is difficult to evaluate fully as other soil forming factors have played a more prominent role. In some instances the relation is clear, for instance, the little differentiated sandy soils that have formed on the relict aeolian sand dunes or the sandy solodic or solod soils that have been derived from the more siliceous and permeable sandstones of the Blythesdale

Group. Also there are the soils that have formed on the various alluvial deposits, the grey soils of heavy texture (Group 2) have obviously formed on a finer textured parent material than, say, the submature red-brown earths, but here again other factors such as surface drainage conditions have also been important. The close association of many of the weakly solodized-solonetz soils (Group 7) to stream lines, both functional and non-functional, that traverse the area dominantly composed of the grey soils of heavy texture, would suggest that they are formed on slightly coarser levee-type materials that permitted some clay eluviation and subsequent horizon differentiation. Once again though the effect of solonisation has further obscured the picture.

There are, however, two extensive groups of quite different soils in which the role played by parent material is not at all clear. These are the strongly gilgaied clay soils and the weakly solonised brown clay loams (Group 6). In both these groups it is not at all clear where the soil profile ends and the parent material commences and in the case of Group 6 soils a further difficulty is that the deeper subsoils consist of the extremely acid clays such as underlie the strongly gilgaied soils. Hence it is difficult to attribute to parent material variation the differences found in the upper levels of the profiles of these two soil groups. The other major difference is the extreme gilgai microrelief that is developed in one group and not in the other. However, these questions will be further discussed in the following sections.

(*d*) Geomorphic Influences and the Role of Past Lateritisation.

It is quite clear from both surface and subsurface evidence that in the past much of the region was subjected to intense lateritisation. In the east where the Blythesdale Group outcrops truncation of the laterite profile has proceeded far enough in certain areas to expose the unaltered sediments below. However, further west even though dissection of the laterite has been much more extensive so that only residuals now remain, in many areas there is still often little or no evidence of the nature or age of the original sediments. One exception is where stripping of the laterite has exposed marine Cretaceous sediments but elsewhere the lateritic residuals are surrounded generally by the strongly gilgaied clay soils (Groups 4 and 5) or by the weakly solonised brown clay loams (Group 6). Subsurface evidence from deep soil borings, excavated earth tanks and available bore logs indicates that in nearly all instances these clay soils are underlain at varying depths by the truncated laterite profile, which consists in most cases of the typical mottled zone material. While the lower levels of the overlying clays may occasionally display a similar red mottling, in almost all instances examined there appears to be a distinct disconformity between these clays and the underlying more indurated typical mottled zone of the laterite profile.

The inference is therefore that following the extensive dissection and truncation of the laterite profile a sequence of clayey sediments was deposited. The varying thickness of this deposit and the presence of numerous lateritic residuals protruding through it indicates that the lateritic basement was very irregular. It may be mentioned at this stage that this association of lateritic residuals and clay soils underlain by a truncated laterite profile is a characteristic feature of much of inland Queensland, and in nearly all cases the soils are the typical strongly gilgaied clays that are described in this report. It would thus seem reasonable to assume that these clays were derived from the dissection of the old laterite profile. However, several problems immediately arise, the most formidable being the fact that these clay soils are dominantly montmorillonitic whereas material derived from the dismembering of a laterite profile would consist essentially of kaolin.

It will be worthwhile now to reconsider briefly the more important features of these clay soils. The most striking aspect is their uniformity of character, not only with depth in any profile but also throughout the extensive areas in which they occur. This is true not only for this region but also for the extensive occurrences in other parts of Queensland. There is never any evidence of stratification or intercalations of coarser material and almost everywhere the clays possess the rather unique chemical features that have been discussed earlier. Thus they contain moderate to high amounts of salt throughout and while the upper horizons may be alkaline with free carbonate the lower levels of the profile are almost invariably strongly to extremely acid even though the clays are still dominantly montmorillonitic. These properties would suggest then that they were deposited or formed under rather specialised environmental conditions or that they were derived from a particular type of uniform parent material. It is also necessary to point out that even in their lower levels these clays show no similarity whatever to the fine sediments that underlie the other heavy grey clay soils of the region (Group 2) and which are of indisputably alluvial origin. In a forthcoming publication (Hubble and Isbell 1958) the nature and relationships of the acid clays have been considered along similar lines to the present discussion.

If it is postulated that these clays were derived originally from a dissected laterite formation it is necessary to account for the present dominance of montmorillonite in them and this would involve synthesis of montmorillonite from kaolin, a process about which little is known. Certainly for such a process to take place both silica and bases would have to be added to the system. Possibly this could be done by assuming a particular closed system environment of deposition, perhaps under stagnant ponded conditions such as exist in present day swamp-like bodies of water. Evidence offering some support for such an environment has been obtained from elsewhere in the State. In the Mackenzie River district in Central Queensland in a region consisting largely of latosolic soils and lateritic residuals there are several lower swampy areas, evidently local inland drainage basins, that contain dark-grey strongly gilgaied (and presumably montmorillonitic) clays that are similarly strongly acid at shallow depths. Whitehouse (1947) has mentioned somewhat similar occurrences in the far south-west of Queensland. Possibly then at some time in the past under different climatic conditions to those obtaining to-day, such swampy conditions may have been much more widespread throughout Queensland and given rise to these vast areas of uniform clay soils.

This theory leaves several phenomena unaccounted for. Firstly, there are the considerable amounts of salt present in almost all of these clay soils and, secondly, the presence of carbonate in the upper levels of many of the soils. Earlier it has been postulated that much of the salt may have been derived from atmospheric accessions and the source of this salt may have been the more inland areas of Australia. It is also feasible that much of the carbonate may have had a similar origin, accessions of calcareous material have been widespread in southern Australia (Crocker 1946), and it is possible that accessions of calcareous material have occurred in this region although a source area is a rather more difficult problem than in southern Australia.

If an aeolian origin is accepted for the salts and carbonates it is also possible that air borne dusts of the same general character as parna (Butler 1956) accompanied the salts and carbonate during their transport and deposition. This mineral material then could have contributed to the upper levels of the present soils and there is the possibility that the entire mass of these clays may be of aeolian origin, although this raises serious problems with regard to their present day occurrence and distribution. However wind activity undoubtedly was prominent in the past in moving and accumulating soil materials. Throughout all but the eastern part of the region there are relict sand dunes that appear to be indisputably of aeolian origin. Many of these are scattered throughout the region of these clays as well as being associated with other soil groups. Deep boring investigations of some of these sands have indicated that their lower horizons are quite different from those of the surrounding clays which become strongly acid at often shallow depths. Possibly these old dunes could represent the complementary coarser fractions of the surrounding fine clays.

From this discussion it is apparent that the nature of many of the factors responsible for the accumulation of these particular clay soils is still very much in doubt. Several hypotheses have been advanced but further evidence is necessary before the full story can be known.

2.—Observations on the Nature and Origin of Gilgai Microrelief.

A characteristic feature of certain soils of the region is the occurrence of gilgai microrelief. In several soil groups such as the grey and brown soils of heavy texture (Groups 2 and 3), the weakly solonised brown clay loams (Group 6) and the weakly solodized-solonetz soils (Group 7) the gilgai structure is only weakly developed with the vertical interval between puff and depression merely of the order of several inches or slightly greater. However, the clay soils supporting a vegetation dominated by brigalow (Groups 4 and 5) are characterised by a very strong development of gilgai microrelief (e.g. Plate 17) with the vertical interval between puff and depression averaging some two to three feet although it may be as great as six feet. The morphology of the puff and depression profiles has been discussed earlier but certain additional factors relating to the occurrence of this strong gilgai may now be mentioned.

The first feature of note in this region is that almost everywhere the occurrence of strong gilgai is associated with a brigalow dominant vegetation and this association is general throughout strong gilgai occurrences elsewhere in Queensland. However, the converse is not necessarily true for there exist many similar clay soil areas supporting a brigalow dominant vegetation but without any gilgai microrelief. Hence it is unlikely that gilgai formation is related in any way to the nature of the vegetation, a conclusion supported by the fact that even if the brigalow is cleared and the land ploughed and levelled the gilgai structure tends to reappear after a period of years. It is evident then that some soil property or combination of properties must be responsible for the development of gilgai.

Hallsworth *et al* (1955) have studied the gilgai soils of New South Wales but it would appear that few of the soils examined by them possessed the extreme gilgai common to certain soils of the present region with which this discussion is primarily concerned. For the New South Wales gilgai soils it was concluded by Hallsworth *et al* after a study of their morphology, chemistry, mechanical composition and clay mineralogy that the distinguishing feature of the gilgai soils was their characteristic swelling pattern on wetting, the topsoils possessing a certain minimum swelling capacity, which increased considerably in the subsoil. For the non-gilgaied soils either the swelling capacity of the subsoil was similar to or less than the topsoil, or if an increase in swelling capacity took place in the subsoil the swelling of the topsoil was less than 10 per cent. This soil swelling was shown to be significantly related to the clay content, the exchange capacity of the clay and the amount of sodium on the exchange complex, all three factors increasing with depth in the depression profiles examined.

This theory was applied to several strongly gilgaied Queensland profiles but with negative results. Instead of the increase of some 15 to 30 per cent. in swelling capacity of the subsoil over the topsoil there was instead a decrease in swelling capacity down the profile for both puff and depression samples. In both cases clay contents remained more or less uniform throughout the profiles. Other soils for which swelling capacities were obtained (volume expansion measured by the modified Keen-Rackowski method—Piper 1942) included the grey soils of heavy texture (Group 2) and the weakly solonised brown clay loams (Group 6). Samples from non-gilgaied sites of these soils showed that in the case of the heavy grey clays a high surface volume expansion (40 per cent.) dropped sharply with depth (20 per cent. below 48 inches), while in the brown clay loams the expansion of the topsoil was less than 10 per cent. These results then are in accordance with the conditions found by Hallsworth *et al* for non-gilgaied soils.

Although insufficient analyses have been conducted to ensure any degree of certainty it would appear likely that for the very strong gilgai development some factors must be involved other than an increase of swelling capacity down the profile. Available particle size analyses show that profiles of strongly gilgaied soils do not invariably show an increase in clay content with depth. It remains then to find some other property or set of properties that is unique to these strongly gilgaied soils. In this connection a possible lead may be gained from the fact that almost invariably in this Goondiwindi-Tara region the deeper subsoils of the strongly gilgaied clays are extremely acid (pH 4·0–5·0). Confirmatory evidence is afforded from some 23 profiles examined to a depth of 6 feet from a wide range of localities in Central Queensland. Of these 23 profiles of strongly gilgaied clay soils all but four were strongly to extremely acid at relatively shallow depths. Complementary studies of 20 non-gilgaied clay soil profiles from the same localities showed that only two became strongly acid with depth.

It is possible therefore that there is some correlation between acid subsoils and a strong gilgai microrelief but at present any such relation is not evident. The lack of strong gilgai development in some widespread soils which are acid at depth (for instance the weakly solonised brown clay loams—Group 6) might be due to the fact that they possess topsoils with a low swelling capacity and thus do not crack extensively. However, just how extremely acid clay subsoils could influence gilgai development is not at all clear.

IX.—ACKNOWLEDGMENTS.

The author is indebted to many persons for assistance during the course of the survey and with the compilation of the report and maps. In particular several officers of the Department of Agriculture and Stock and the C.S.I.R.O. have visited parts of the region with the author and have contributed to discussions of various soil problems. Special thanks are due to Mr. G. D. Hubble of the C.S.I.R.O. Division of Soils for his invaluable assistance in discussions and criticisms of the manuscript. The analytical work was carried out by the Department of Agriculture and Stock and thanks are due to those officers, Messrs. I. F. Fergus, J. D. Hughes and C. E. Rose, who under the leadership of Mr. C. R. von Stieglitz were mainly responsible for the soil analyses.

The Commonwealth Meteorological Bureau supplied available meteorological data and plant specimens were indentified by Dr. S. T. Blake of the Department of Agriculture and Stock. Mr. G. W. Tweedale of the Geological Survey accompanied the writer on one visit to the area and contributed to the compilation of the geological map.

Finally acknowledgment is made to unpublished work on the region by Mr. P. J. Skerman and Mr. G. H. Allen, formerly of the Bureau Staff, and to Mr. D. Buckley for invaluable assistance with the preliminary drafting work associated with the maps.

X.—REFERENCES.

BEADLE, N. C. W. (1948).—" Vegetation and Pastures of Western New South Wales, with special reference to soil erosion." (Govt. Printer : Sydney).

BIRCH, H. F. (1951).—Relationship between base saturation and crop response to phosphate in acid soils. Nature 168 : 388.

BLAKE, S. T. (1938).—The plant communities of Western Queensland and their relationships with special reference to the grazing industry. Proc. Roy. Soc. Qld. **XLIX** : 156–204.

BURVILL, G. H. AND TEAKLE, L. J. H. (1938).—The occurrence of solonetz (Structural alkali) soils in Western Australia. Jour. Agric. West. Aust. **15** : 97–109.

BUTLER, B. E. (1956).—Parna—an aeolian clay. Aust. J. Sci. **18** : 145.

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION (1953).—Standardised Plant Names. Bull. No. 272.

CROCKER, R. L. (1946).—Post-Miocene climatic and geologic history and its significance in relation to the genesis of the major soil types of South Australia. Coun. Sci. Industr. Res. Aust. Bull. No. 193.

DIVISION OF RECONSTRUCTION AND DEVELOPMENT (1950).—The Namoi region : a preliminary survey of resources (Mimeo.) (Premier's Department : Sydney).

DIVISION OF RECONSTRUCTION AND DEVELOPMENT (1951).—The New England region : a preliminary survey of resources. (Mimeo.) (Premier's Department : Sydney).

DOWNES, R. G. (1954).—Cyclic salt as a dominant factor in the genesis of soils in south-eastern Australia. Aust. J. Agric. Res. **5** : 448.

DOWNES, R. G. AND SLEEMAN, J. R. (1955).—The soils of the Macquarie Region, New South Wales. C.S.I.R.O. Aust. Soil Pub. No. 4.

FOLEY, J. C. (1945).—Frost in the Australian region. Commonw. Met. Bur. Aust. Bull. No. 32.

GEDROIZ, K. K. (1912).—Colloidal chemistry as related to soil science. Zhur. Opit. Agron. **13** : 363. (Quoted in Kelley 1951).

HALLSWORTH, E. G. AND COSTIN, A. B. (1950).—Soil classification. J. Aust. Inst. Agric. Sci. **16** : 84.

HALLSWORTH, E. G., COSTIN, A. B. AND GIBBONS, F. R. (1953).—Studies in pedogenesis in New South Wales. VI. On the classification of soils showing features of podsol morphology. J. Soil Sci. **4** : 241.

HALLSWORTH, E. G., ROBERTSON, G. K. AND GIBBONS, F. R. (1955).—Studies in pedogenesis in New South Wales. VII. The gilgai soils. J. Soil Sci. **6** : 1.

HOUNAM, C. E. (1950).—Climate of the north-west wheat belt of New South Wales with special reference to rainfall over marginal areas. Commonw. Met. Bur. Aust. Pamp. No. 4.

HUBBLE, G. D. AND ISBELL, R. F. (1958).—The occurrence of strongly acid clays beneath alkaline soils in Queensland. Aust. J. Sci. **20** : 186.

HUBBLE, G. D. AND THOMPSON, C. H. (1953).—The soils and land use potential of the Lower Burdekin Valley, North Queensland. C.S.I.R.O. Aust. Div. Soils, Soils Land Use Ser. No. 10.

ISBELL, R. F. (1954).—An investigation of the Callide, Don and Dee valleys, Queensland. Qld. Bur. Investigation Tech. Bull. No. 3.

ISBELL, R. F. (1954).—Survey of the Nebo-Collinsville region, Queensland. Qld. Bur. Investigation Tech. Bull. No. 4.

JOHNSTONE, E. J. (1953).—Pedology of the Deniboota Irrigation District, New South Wales. C.S.I.R.O. Aust. Soil Pub. No. 1.

KELLEY, W. P. (1951).—" Alkali Soils." (Reinhold : New York).

KELLOGG, C. E. (1949).—Preliminary suggestions for the classification and nomenclature of great soil groups in tropical and equatorial regions. Comm. Bur. Soil Sci. Tech. Comm. No. 46.

KERR, H. W. AND VON STIEGLITZ, C. R. (1938).—The laboratory determination of soil fertility. Qld. Bur. Sugar Expt. Stn. Tech. Comm.

PIPER, C. S. (1942).—" Soil and Plant Analyses." (Hassel Press : Adelaide).

PRESCOTT, J. A. (1931).—The soils of Australia in relation to vegetation and climate. Coun. Sci. Industr. Res. Aust. Bull. No. 52.

PRESCOTT, J. A. AND SKEWES, H. R. (1941).—An examination of some soils from tropical Australia. Trans. Roy. Soc. S. Aust. **65** : 123.

PRESCOTT, J. A. AND THOMAS, J. A. (1949).—The length of the growing season. Proc. R. Geogr. Soc. Aust. S. Aust. Br. **50** : 42.

SKERMAN, P. J. (1951).—Soils (of Queensland). Handbook A.N.Z.A.A.S., Brisbane : 75.

SKERMAN, P. J. (1953).—The brigalow country and its importance to Queensland. J. Aust. Inst. Agric. Sci. **19** : 167.

STEPHENS, C. G. (1953).—" A Manual of Australian Soils." (C.S.I.R.O. Aust. : Melbourne.)

STEWART, G. A. (1956).—The soils of the Katherine-Darwin region, Northern Territory. C.S.I.R.O. Aust. Soil Pub. No. 6.

STIRK, G. B. (1954).—An index for rating the physical status of soils. C.S.I.R.O. Aust. Div. Soils, Divl. Rep. 4/54.

STOUT, P. R. (1949).—Recent inorganic chemical interpretations of soil systems as a medium for plant growth. Proc. Specialist Conference in Agriculture. Aust. : 58.

WHITEHOUSE, F. W. (1940).—Studies on the late geological history of Queensland. Univ. Qd. Pap. Dep. Geol. (N.S.) **2** (1) : 1.

WHITEHOUSE, F. W. (1947).—The geology of the Channel Country of south-western Queensland. Qld. Bur. Investigation Tech. Bull. No. 1 : 10.

WHITEHOUSE, F. W. (1952).—" The Mesozoic Environments of Queensland." A.N.Z.A.A.S., **XXIX** : 83.

WHITEHOUSE, F. W. (1954).—Artesian Water Supplies in Queensland—Appendix G. (Govt. Printer : Brisbane).

APPENDIX I.

Glossary of the more common plant Species occurring in the Region.

Common Name.	Botanical Name.
Trees—	
Apple, rough-barked	*Angophora intermedia* DC.
Belah	*Casuarina lepidophloia*. F. Muell.
Bitter bark	*Alstonia constricta*. F. Muell.
Bloodwood	*Eucalyptus trachyphloia*. F. Muell. *Eucalyptus polycarpa*. F. Muell.
Boonarie	*Heterodendron oleifolium* Desf.
Bottle tree	*Brachychiton rupestrie* (Lindl.) Terr.
Box, Poplar	*Eucalyptus populnea*. F. Muell.
Mallee	*Eucalyptus pilligaensis*. Maid.
Brigalow	*Acacia harpophylla*. F. Muell.
Bull Oak	*Casuarina leuhmannii*. R. T. Bak.
Coolibah	*Eucalyptus microtheca*. F. Muell.
Cypress pine	*Callitris glauca*. R. Br.
Emu Apple	*Owenia acidula*. F. Muell.
Gum, River	*Eucalyptus camaldulensis*. Dehnh.
Rusty	*Angophora costata* (Gaertn.) J. Britten.
Tumbledown	*Eucalyptys dealbata*. A. Cunn.
Ironbark, Narrow leaf	*Eucalyptus crebra*. F. Muell.
Silver leaf	*Eucalyptus melanophloia*. F. Muell.
Ironwood	*Acacia excelsa*. Benth.
Kurrajong	*Brachychiton populneum*. R. Br.
Lancewood	*Acacia sparsiflora*. Maid.
Leopard wood	*Flindersia maculosa*. F. Muell.
Moreton Bay ash	*Eucalyptus tessellaris*. F. Muell.
Myall	*Acacia pendula*. A. Cunn.
Nelia	*Acacia oswaldii*. F. Muell.
Quinine berry	*Petalostigma pubescens*. Domin.
Red ash	*Alphitonia exclesa* (Fenzl) Benth.
Sandalwood (budda)	*Eremophila mitchellii*. Benth.
Tea tree, black	*Melaleuca pubescens*. Schauer.
a paper bark	*Melaleuca adnata*. Turcz.
Thready bark oak	*Casuarina inophloia*. F. Muell and F. M. Bail.
Wattle	*Acacia cunninghamii*. Hook.
Whitewood	*Atalaya hemiglauca*. F. Muell.
Wilga	*Geijera parviflora*. Lindl.
Yapunyah	*Eucalyptus thozetiana*. F. Muell ex. R. T. Bak.
Shrubs—	
Currant bush	*Carissa ovata*. R. Br.
Fuchsia bush	*Eremophila maculata* (Ker) F. Muell.
Gooramurra	*Eremophila bignoniiflora* (Benth) F. Muell.
Lignum	*Muehlenbeckia cunninghamii* (Meion) F. Muell.
Limebush	*Eremocitrus glauca* (Lindl) Swingle.
Orange	*Capparis mitchellii*. Lindl.
River Wattle	*Acacia stenophylla*. A. Cunn.

APPENDIX I.—*continued.*

Common Name.	Botanical Name.
GRASSES—	
Bamboo grass, slender	*Stipa verticillata.* Nees.
Blady grass	*Imperata cylindrica* (L) Beauv. var. *major* (Nees) C. E. Hubbard.
Blue grass, forest	*Bothriochloa intermedia.* A. Camus.
pitted	*Bothriochloa decipiens.* C. E. Hubbard.
Queensland	*Dichanthium sericeum.* A. Camus.
Brigalow grass	*Paspalidium caespitosum.* C. E. Hubbard.
	Paspalidium gracile (R.Br.) Hughes.
Brown top	*Eulalia fulva* (R.Br.) Kuntze.
Button grass	*Dactyloctenium radulans* (R.Br.) Beauv.
Cane grass	*Leptochloa digitata* (R.Br.) Domin.
Chloris, slender	*Chloris divaricata* R. Br.
Comet grass	*Perotis rara* R.Br.
Early Spring grass	*Eriochloa pseudoacrotricha* (Stapf ex Thell). C. E. Hubbard ex. S. T. Blake.
Fairy grass	*Sporobolus caroli.* Mez.
Flinders grass—small	*Iseilema membranaceum* (Lindl.)
Golden beard grass	*Chrysopogon fallax.* S. T. Blake.
Kangaroo grass	*Themeda australis* (R.Br.) Stapf.
Love grass, purple	*Eragrostis lacunaria.* F. Muell.
paddock	*Eragrostis leptostachya.* Steud.
weeping	*Eragrostis parviflora* (R.Br.) Trin.
	Eragrostis molybdea. J. Vickery.
	Eragrostis speciosa. Steud.
Millet, native	*Panicum decompositum.* R.Br.
Mitchell grass, curly	*Astrebla lappacea* (Lindl.) Domin.
Nut grass, downs	*Cyperus retzii.* Nees.
Shot grass	*Paspalidium globideum* (Domin) Hughes.
Spear grass, black	*Heteropogon contortus* (L.) Beauv.
Water grass	*Thellungia advena* Stapf. ex Thell.
Windmill grass	*Chloris truncata* R.Br.
curly	*Chloris acicularis* Lindl.
Wire grass, purple	*Aristida ramosa* R.Br.
	Aristida caput-medusae Domin.
	Aristida echinata Henr.
	Aristida jerichoensis Domin.
	Aristida latifolia Domin.
MISCELLANEOUS PLANTS—	
Bathurst burr	*Xanthium spinosum* L.
Bogan flea	*Calotis hispidula* F. Muell.
Brigalow burr	*Bassia tetracuspis* C. T. White.
Burr Medic	*Medicago denticulata* Willd.
Burr Medic, small woolly	*Medicago minima* (L) Bartal.
Cotton bush	*Kochia tomentosa* var *brevifolia* F. Muell.
Darling pea	*Swainsona sp.*
Galvanised burr	*Bassia birchii* F. Muell.
Mexican poppy	*Argemone mexicana* L.
Nardoo	*Marsilea drummondii* A. Br.
Roly-poly	*Bassia quinquecuspis* F. Muell.
Saltbush, creeping	*Atriplex semibaccata* R.Br.
Spinifiex	*Triodia irritans* R.Br.
Twin leaf	*Zygophyllum apiculatum* F. Muell.

APPENDIX II.

Analytical Data for Representative Soils.

The following symbols have been used in the tables as abbreviations of texture :—S, sand ; LS, loamy sand ; CS, clayey sand ; SL, sandy loam ; L, loam ; SCL, sandy clay loam ; FSCL, fine sandy clay loam ; CL, clay loam ; SiCL, silty clay loam ; SC sandy clay ; SiC, silty clay ; C, clay ; LC, light clay ; MC medium clay ; HC, heavy clay.

Analytical data have been expressed on an air-dry basis. Methods used are in general those described by Piper (1942) with the following modifications :—

Soil Reaction.—Determined on a 1 : 2·5 soil : water suspension.

Phosphorus.—" Available " phosphate determined by the method of Kerr and von Stieglitz (1938).

Exchangeable Cations.—Soil leached with N/20 HCl, calcium, magnesium and sodium determined as per Piper, potassium determined using an E.E.L. flame photometer. Exchangeable hydrogen determination is based on the metanitrophenol method as detailed in Piper (to pH 8·4), exchange capacity calculated by summation of individual cations.

Specific Conductivity.—Results calculated at 25°C

Mechanical Analyses.—Carried out by the standard pipette method.

APPENDIX II.—*continued.*

Mapping Unit. Great Soil Group. Location.	Recent Alluvial Soil Association. Alluvial Soil. Lower terrace of Macintyre Brook near Whetstone Weir.							Recent Alluvial Soil Association. Alluvial Soil. Macintyre Brook near Whetstone Weir.						Recent Alluvial Soil Association. Submature Red-Brown Earth. Back levee slope, Macintyre Brook near Whetstone Weir.		
Lab. No.	1978	1979	1980	1981	1982	1983	1984	1969	1970	1971	1972	1973	1974	1975	1976	1977
Depth (in.)	0–6	6–28	28–43	43–60	60–80	80–103	103–120	0–8	8–16	16–28	28–54	54–68	68–74	0–7	7–22	22–44
Horizon	1	2	3	4	5	6	7	1	2	3	4	5	6	A_1	A_3	B_2
Texture	SiL	SiCL	SiL	CL	L	L	L	L	L	L	L	L	L	SiL	SiL	SiCL
pH	6·4	6·3	7·1	7·1	7·8	7·9	7·8	6·9	6·9	6·6	7·0	8·2	9·2	6·3	6·7	6·8
Mech. Analysis (%)—																
Coarse sand	3·2	3·2	4·5	5·7	17·8	21·1	17·1	9·2	11·2	13·9	12·1	12·5	17·0	3·1	4·7	3·6
Fine sand	50·2	37·6	44·8	47·6	45·0	46·7	50·6	58·1	54·6	53·3	50·0	51·5	48·8	48·6	41·9	42·7
Silt	26·0	22·6	21·1	17·3	13·8	15·8	9·6	16·3	16·8	16·9	15·4	18·9	17·3	24·0	24·4	21·9
Clay	17·1	27·8	25·4	25·1	18·0	15·6	18·9	16·1	16·6	14·1	22·0	16·1	15·0	20·8	23·3	28·2
Loss on acid treatment	1·2	2·6	1·0	1·3	1·0	0·4	0·7	1·0	0·8	0·07	0·5	0·6	1·4	1·2	1·2	0·6
Moisture	1·8	4·5	4·1	3·5	2·9	2·4	2·4	1·4	1·9	1·9	3·2	2·7	2·3	1·4	3·3	3·6
Organic carbon (%)	1·1							0·56						0·82		
Nitrogen (%)	0·11							0·07						0·09		
Available P_2O_5 (ppm)	140	130	130	145	165	110	95	197	160	65	200	360	405	120	66	32
Chloride as NaCl (%)	0·011	0·005	0·005	—	0·003	—	—	0·002	0·003	0·003	0·007	0·010	0·008	0·005	0·003	0·002
Specific Conductivity (mhos x10^{-3})	0·123	0·090	0·030	0·031	0·040	0·030	0·033	0·033	0·035	0·269	0·083	0·123	0·217	0·091	0·039	0·030
Exchangeable cations:	A B	A B	A	A	A	A	A	A B	A B	A	A	A		A B	A B	A B
Calcium	10·0 63	11·5 61	8·7	11·4	7·8	3·9	5·1	6·5 62	6·0 54	3·3	5·4	6·2		6·2 55	8·0 59	6·2 44
Magnesium	3·8 24	5·3 28	4·3	4·5	4·1	4·9	5·1	2·3 22	3·3 30	2·2	4·6	6·7		2·7 24	3·8 28	6·4 46
Potassium	1·3 81	1·1 6						1·4 13	1·4 12					1·9 17	1·1 8	0·8 6
Sodium	0·8 5	1·0 5	0·7	0·4	0·4	0·4	0·5	0·4 3	0·4 4	0·5	2·2	2·4		0·4 4	0·7 5	0·5 4
Total Metal ions	15·9 100	18·9 100						10·6 100	11·1 100					11·2 100	13·6 100	13·9 100

A = mg. equiv./100 g. of soil. B = percentage composition of the exchangeable metal ions.

APPENDIX II.—*continued.*

Mapping Unit. Great Soil Group. Location.	Recent Alluvial Soil Association. Submature Red-Brown Earth. *Adjacent to Dumaresq River near Beebo.*					Grey Soil of Heavy Texture Association. Grey Soil of Heavy Texture. ¾ mile south of Toobeah.								
Lab. No.	761	762	763	764	765	1562	1563	1564	1565	1566	1634	1635	1636	1637
Depth (in.)	0–10	10–24	24–36	36–48	48–67	0–6	6–12	12–24	24–36	48–66	72–84	108–120	144–156	180–192
Horizon	A_1	B_1	B_{21}	B_{22}	BC	1	2	3	4	AC	C	C	C	C
Texture	L	CL	C	C	C	HC	HC	HC	HC	MC	LC	LC	LC	LC
pH	5·7	6·5	8·2	8·4	8·7	7·8	7·8	7·3	7·2	6·8	7·4	7·1	6·1	5·8
$CaCO_3$						—	0·23*	0·04						
Mech. analysis (%)—														
Coarse sand						0·9		0·7		0·9				2·6
Fine sand						6·6		5·4		7·3				56·4
Silt						17·8		17·4		21·9				13·5
Clay						66·5		66·6		63·1				28·0
Loss on acid treatment						2·3		2·0		2·2				
Moisture						7·9		8·1		7·0				2·5
Organic carbon (%)	0·45	0·15				0·71	0·62							
Nitrogen (%)	0·05	0·04				0·07	0·08							
Available P_2O_5 (ppm)	92	42	76	70	52	66	42	46	43	95				
Chloride as NaCl (%)						0·009	0·022	0·198	0·219	0·742	0·153	0·153	0·132	0·144
Specific conductivity (mhos x 10^{-3})	—	—	0·005	0·015	0·015	0·092	0·203	0·920	1·096	1·189	0·740	0·677	0·577	0·486
Exchangeable cations:	A B	A B	A B	A B	A B	A B	A B							
Calcium	5·5 60	3·8 45	5·8 38	4·5 30	8·8 39	26·5 58	25·4 53							
Magnesium	2·9 32	3·5 42	5·1 34	6·2 42	8·6 39	16·8 37	19·6 40							
Potassium	0·2 2	0·2 2	0·2 2	0·2 1	0·3 1	0·9 2	0·9 2							
Sodium	0·6 6	0·9 11	4·0 26	4·0 27	4·6 21	1·5 3	2·7 5							
Total Metal ions	9·2 100	8·4 100	15·1 100	14·9 100	22·3 100	45·7 100	48·6 100							
Exch. Hydrogen						4·8								
Saturation (%)						90								
Exchange Capacity*						76								

A = mg. equiv./100 g. of soil. B = *percentage composition of the exchangeable metal ions.* * mg. equiv./100 g. clay.

APPENDIX II.—*continued.*

Mapping Unit.	Grey Soil of Heavy Texture Association.							Grey and Brown Soil of Heavy Texture Association.							
Great Soil Group.	Grey Soil of Heavy Texture.							Grey Soil of Heavy Texture.				Brown Soil of Heavy Texture.			
Location.	2 miles south of Commoron Creek, Goondiwindi–Goodar road.							5 miles north of Coomrith on Coomoomie road.				Myallstone race track south of Meandarra. Linear gilgai on sloping site, puff profile.			
Lab. No.	228	229	230	231	1527	1528	1529	1640	1641	1642	1643	1632	1633	1634	1635
Depth (in.)	0–6	6–12	12–24	24–36	36–50	50–60	60–70	0–12	12–33	33–48	48–60	0–3	3–12	12–36	36–54
Horizon	1	2	3	4	AC	C	C	1	2	AC	C	1	2	3	AC
Texture	HC	HC	HC	HC	MC	MC	MC	HC	HC	MC	MC	LC	MC	MC	MC
pH	7·4	7·3	7·1	6·9	7·3	7·4	7·4	7·9	8·1	8 0	7·9	8·0	8·1	8·3	8·4
$CaCO_3$ (%)	tr.	tr.						4·14	2·50	4·95	2·92	12·25	8·66	14·76	10·89
Mech. Analysis (%)—															
Coarse sand		1·6													
Fine sand		8·3													
Silt		19·0													
Clay		63·0													
Loss on acid treatment		1·7													
Moisture		8·5													
Organic carbon (%)	0·75	0·78						1·13	1·33	1·33		1·50	1·12	0·85	
Nitrogen (%)	0·05	0·04						0·11	0·08	0·05		0·12	0·08	0·06	
Available P_2O_5 (ppm)	46	36	28	42	104	138	152	104	120	62	38	36	26	—	38
Chloride as NaCl (%)	—	0·140	0·410	0·568	0·479	0·450	0 440	0·025	0·013	0·268	0·248	0·012	0·012	0·025	0·062
Specific conductivity (mhos x 10^{-3}) ..	—	0·59	1·77	2·41	2·12	1·98	1·95	0·214	0·816	1·440	1·376	0·141	0·173	0·336	0·552
Exchangeable cations:	A B	A B						A B	A B		A B	A B	A B		A B
Calcium	20·3 51	19·5 46						19·4 64	11·7 49		13·3 54	17·6 76	12·3 59		9·6 42
Magnesium	15·1 37	17·3 41						7·7 26	8·2 34		9·1 37	2·9 13	5·6 27		9·4 41
Potassium	0·7 2	0·7 2						0·7 2	0·5 4		0·3 1	1·1 5	0·5 3		0·3 1
Sodium	3·9 10	4·7 11						2·4 8	3·6 13		1·7 8	1·5 6	2·3 11		3·7 16
Total Metal ions	40·0 100	42·2 100						30·2 100	24·0 100		24·4 100	23·1 100	20·7 100		23·0 100

A = mg. equiv./100 g. of soil. B = percentage composition of the exchangeable metal ions.

APPENDIX II.—*continued.*

Mapping Unit. Great Soil Group. Location.	Grey and Brown Soil of Heavy Texture Association. Grey Soil of Heavy Texture. Myallstone race track south of Meandarra. Linear gilgai on sloping site, depression profile.				Grey Clay Association. Closely related to Grey Soil of Heavy Texture. 6 miles north-west of Yelarbon. Puff profile.					Grey Clay Association. Closely related to Grey Soil of Heavy Texture. 6 miles north-west of Yelarbon. Depression profile.					
Lab. No.	1636	1637	1638	1639	242	243	244	245	246	247	248	249	250	251	252
Depth (in.)	0–4	4–20	20–30	30–42	0–14	14–24	24–36	36–48	48–60	0–12	12–24	24–36	36–48	48–60	60–72
Horizon	1	2	3	AC	1	2	3	4	5	1	2	3	4	5	6
Texture	MC	MC	HC	MC	HC	HC	HC	HC	HC	MC	MC	HC	HC	HC	HC
pH	7·2	6·5	7·9	8·0	8·0	8·1	7·7	5·2	4·8	7·2	8·1	8·2	8·3	8·4	8·2
$CaCO_3$ (%)	0·11	—	0·21	4·42	0·34	0·38				1·84					
Organic carbon (%)	1·88	1·49	0·73		0·67	0·32				2·92	1·67				
Nitrogen (%)	0·13	0·10	0·07		0·08	0·07				0·25	0·16				
Available P_2O_5 (ppm)	42	34	32	66	26	26	22	12	12	296	66	22	22	28	26
Chloride as NaCl (%)	0·004	0·025	0·095	0·083	0·012	0·064	0·098	0·134	0·171	0·017	0·017	0·044	0·071	0·102	0·106
Specific conductivity (mhos x 10^{-3}) ..	0·058	0·150	0·512	0·525	0·210	0·500	0·680	0·920	0·950	0·180	0·120	0·220	0·400	0·530	0·510
Exchangeable cations:	A B	A B		A B	A B	A B				A B	A B				
Calcium	9·3 61	11·6 58		12·8 54	34·9 68	17·4 42				48·5 79	35·5 80				
Magnesium	4·5 29	6·5 32		7·9 33	13·5 26	17·0 41				8·6 14	5·7 13				
Potassium	0·8 5	0·2 1		0·4 2	0·7 1	1·0 3				1·8 3	0·7 2				
Sodium	0·7 5	1·8 9		2·6 11	2·5 5	5·6 14				2·5 4	2·5 5				
Total Metal ions	15·3 100	20·1 100		23·7 100	51·6 100	41·0 100				61·4 100	44·4 100				

A = mg. equiv./100 g. of soil. B = percentage composition of the exchangeable metal ions.

APPENDIX II.—*continued.*

Mapping Unit. Great Soil Group. Location.	Grey Clay Association. Closely related to Grey Soil of Heavy Texture. 3 miles south of Tara, puff profile.					Grey Clay Association. Closely related to Grey Soil of Heavy Texture. 3 miles south of Tara, depression profile.					Grey Clay Association. Closely related to Grey Soil of Heavy Texture. Weir highway, ¼ mile south of Moonie highway. Flat puff profile.			
Lab. No.	1622	1623	1624	1625	1626	1627	1628	1629	1630	1631	2162	2163	2164	2165
Depth (in.)	0–10	10–24	24–36	36–48	48–60	0–12	12–24	24–36	36–48	48–60	0–2	2–12	12–24	24–36
Horizon	1	2	3	4	5	1	2	3	4	5	1	2	3	4
Texture	HC	HC	HC	HC	HC	HC	HC	HC	HC	HC	MC	HC	HC	HC
pH	7·3	5·7	4·8	4·4	4·5	7·0	7·5	6·0	4·5	4·4	8·3	8·4	8·3	6·9
$CaCO_3$ (%)	0·09	—	—	—	—	0·19	0·16	—	—	—	5·54	0·36	0·34	0·17
Mech. analysis (%)—														
Coarse sand	9·9	8·6	9·4	8·6	9·4	13·0	13·3	11·4	12·6	12·6				
Fine sand	27·7	26·3	26·7	21·8	26·6	25·2	17·8	26·6	28·0	28·2				
Silt	14·0	12·0	12·0	12·0	13·0	12·0	13·0	14·0	12·0	12·0				
Clay	42·0	46·0	44·4	51·4	44·4	43·4	48·4	41·4	41·4	41·4				
Loss on acid treatment	1·4	2·1	1·0	0·9	1·0	1·7	1·7	1·9	1·3	0·8				
Moisture	6·1	6·6	6·5	6·3	6·6	6·2	6·0	6·2	5·5	5·7				
Volume expansion (%)	21·4	19·0	16·5	16·9	17·0	30·1		16·9	14·3	17·7				
Organic carbon (%)	0·96	0·63	0·45			1·46	0·65	1·31			0·7	0·5		
Nitrogen (%)	0·11	0·08	0·07			0·08	0·07	0·06			0·07	0·02		
Available P_2O_5 (ppm)	26	18	16	36	12	18	18	14	32	18	58	8	30	20
Phosphorous P_2O_5 (%)	0·009	0·006	0·005	0·006	0·006	0·009	0·008	0·007	0·013	0·006				
Chloride as NaCl (%)	0·182	0·219	0·210	0·231	0·240	0·012	0·021	0·087	0·153	0·171				
Specific conductivity (mhos x 10^{-3})	1·120	1·088	1 056	1·152	1·184	0 078	0·118	0·422	0·656	0·784	0·178	0·816	1·478	1·411
Exchangeable cations :	A B	A B	A B	A B	A B	A B	A B	A B	A B	A B	A B	A B		
Calcium	13·3 47	8·6 37	5·6 30	4·2 23	5·3 27	12·0 55	13·6 54	7·8 42	4·5 27	3·8 19	16·3 56	8·8 31		
Magnesium	11·9 42	10·6 46	8·4 45	8·2 46	8·7 45	7·0 32	7·7 31	8·8 48	7·0 42	7·0 34	9·8 34	13·5 47		
Potassium	0·6 3	0·2 1	0·2 1	0·2 1	0·3 1	0·9 4	0·4 2	0·2 1	0·2 1	0·2 1	0·9 3	0·7 3		
Sodium	2·2 8	3·7 16	4·5 24	5·4 30	5·2 27	1·9 9	3·3 13	1·6 9	5·0 30	9·3 46	2·1 7	5·5 19		
Total Metal ions	28·0 100	23·1 100	18·7 100	18·0 100	19·5 100	21·8 100	24·0 100	18·4 100	16·7 100	20·3 100	29·1 100	28·5 100		
Exch. Hydrogen	2·2	4·7			7·8	4·1		5·6		7·6				
Saturation (%)	93	83			71	84		77		73				
Exchange Capacity*	72	60			61	59		58		67				

A = mg. equiv./100 g. of soil. B = percentage composition of the exchangeable metal ions. * mg. equiv./100 g. of clay.

APPENDIX II.—*continued.*

Mapping Unit. / Great Soil Group. / Location.	Grey Clay Association. Closely related to Grey Soil of Heavy Texture. 3 miles south-east of Glenmorgan along the Meandarra road. Puff profile.							
Lab. No.	1460	1461	1462	1463	1464	1465	1466	1467
Depth (in.)	0–6	6–12	12–24	24–36	36–48	48–60	60–66	66–72
Horizon	1	2	3	4	5	6	7	8
Texture	HC	HC	HC	HC	HC	HC	HC	HC
pH	6·4	6·1	5·0	4·4	4·2	4·2	4·2	4·1
Clay percentage	48·0			46·0				46·7
Volume expansion (%)	24·6			13·1			17·8	
Available P_2O_5 (ppm)	14	36	32	22	18	16		
Chloride as NaCl (%)	0·026	0·060	0·186	0·338	0·373	0·375	0·386	0·429
Specific conductivity (mhos x 10^{-3})	0·14	0·34	0·88	1·44	1·60	1·57	1·60	1·73
Exch. Sodium (m. equiv./100 g. soil) ..	2·2	2·7	3·1	3·0	2·9	4·2	0·3	0·4

Mapping Unit. / Great Soil Group. / Location.	Grey Clay Association. Closely related to Grey Soil of Heavy Texture. 3 miles south-east of Glenmorgan along the Meandarra road. Depression profile.							
Lab. No.	1468	1469	1470	1471	1472	1473	1474	1475
Depth (in.)	0–6	6–12	12–24	24–36	36–48	48–60	60–66	66–72
Horizon	1	2	3	4	5	6	7	8
Texture	HC	HC	HC	HC	HC	HC	HC	HC
pH	6·0	5·6	4·7	4·6	4·5	4·4	4·5	4·4
Clay percentage	48·2			48·5				48·2
Volume expansion (%)	17·1			15·3			17·9	
Available P_2O_5 (ppm)	32	20	12	28	28	26	12	
Chloride as NaCl (%)	0·013	0·116	0·290	0·327	0·355	0·375	0·388	0·398
Specific conductivity (mhos x 10^{-3})	0·09	0·51	1·22	1·36	1·50	1·54	1·60	1.65
Exch. Sodium (m. equiv./100 g. soil) ..	2·4	2·0	2·0	2·3	1·9	1·8	0·8	0·5

APPENDIX II.—*continued.*

Mapping Unit. Great Soil Group. Location.	Brown Clay Association. Closely related to Brown Soil of Heavy Texture. 2·3 miles north of the Moonie River, Westmar–Meandarra road.												Brown Clay Association. Closely related to Brown Soil of Heavy Texture. 7 miles south of Burloo Station. Bungunya–Springmount road.			
Lab. No.	222	223	224	1488	1489	1490	1638	1639	1640	1641	1642	1643	1558	1559	1560	1561
Depth (in.)	0–10	10–26	26–36	36–50	50–60	60–70	72–84	84–96	102–108	108–120	120–132	132–144	0–4	4–12	12–26	26–36
Horizon	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
Texture	MC	HC	HC	HC	HC	HC	MC	MC	HC	HC	HC	HC	LC	MC	HC	HC
pH	7·9	7·9	8·2	7·9	7·3	5·3	3·9	3·8	3·6	3·6	3·6	3·6	6·9	7·7	8·4	8·0
$CaCO_3$ (%)	2·85	5·94	11·18										—	1·60	6·70	1·49
Mech. Analysis (%)—																
Coarse sand		5·9						1·4		1·5						
Fine sand		29·9						23·3		21·6						
Silt		17·0						11·5		15·5						
Clay		40·5						58·2		57·0						
Moisture		5·3						6·4		6·7						
Organic carbon (%)	1·01	0·30											1·92	1·19		
Nitrogen (%)	0·06	0·03											0·20	0·12		
Available P_2O_5 (ppm)	32	14	10	8	4	4							45	50	25	19
Chloride as NaCl (%)	0·021	0·267	0·203	0·256	0·276	0·282	0·269	0·271	0·284	0 294	0·322	0·323	0 002	0·024	0·068	
Specific conductivity (mhos x 10^{-3})	0 20	1·40	1·05	1·37	1·40	1·40	1·25	1 26	1·28	1·34	1·44	1·45	0·051	0·219	0·634	1·240
Exchangeable cations:	A B	A B						A B		A B			A B	A B		
Calcium	21·3 77	23·0 55						8·6 41		8·0 41			18·3 68	25·2 65		
Magnesium	4·0 14	14·1 34						10·5 50		10·9 55			7·0 26	10·4 29		
Potassium	0·6 3	0·2 1						0·2 1		0·2 1			1·2 4	1·1 2		
Sodium	1·8 6	4·1 10						1·7 8		0·5 3			0·4 2	1·5 4		
Total Metal ions	27 7 100	41·4 100						21·0 100		19·6 100			26·9 100	38·2 100		
Exch. Hydrogen								14·9		22·5						
Saturation (%)								58		47						
Exchange Capacity*								66		74						

A = mg. equiv./100 g. of soil. B = percentage composition of the exchangeable metal ions. * mg. equiv./100 g. clay.

APPENDIX II.—*continued.*

Mapping Unit.	Weakly Solonised Brown Clay Loam Association.							Weakly Solonised Brown Clay Loam Association.						
Great Soil Group.	Related to Grey and Brown Soils of Heavy Texture, Red-Brown Earths and Solodized-Solonetz.							Related to Grey and Brown Soils of Heavy Texture, Red-Brown Earths and Solodized-Solonetz.						
Location.	5 miles north of Southwood on the Hannaford road.							2 miles south-west of Yelarbon along the Kurumbul road.						
Lab. No.	1615	1616	1617	1618	1619	1620	1621	1514	1515	1516	1517	1518	1519	1520
Depth (in.)	0–2	2–3	3–14	14–24	24–40	40–48	48–60	0–4	4–15	15–24	24–36	36–48	48–60	60–70
Horizon	A_1	A_2	B_{21}	B_{22}	BC			A_1	B_{21}	B_{22}	BC			
Texture	CL	CL	HC	MC	MC	HC	HC	CL	HC	MC	MC	HC	HC	HC
pH	6·7	7·5	7·2	7·9	7·8	6·9	4·8	6·6	7·7	8·4	8·5	7·7	5·1	4·8
$CaCO_3$ (%)	—	0·123	0·068	0·582	0·114	—	—	—	—	—				
Mech. analysis (%)—														
Coarse sand	22·1	16·5	11·6	11·1	13·9	15·6	16·3							
Fine sand	36·0	40·6	22·8	23·8	28·4	24·3	23·3							
Silt	16·4	19·0	12·0	13·0	12·0	12·0	13·0							
Clay	22·9	21·0	46·4	45·0	39·4	42·4	41·4							
Loss on acid treatment	0·8	0·6	1·7	2·1	1·4	1·2	1·2							
Moisture	2·3	2·0	6·9	7·0	6·2	5·7	5·8							
Volume expansion (%)	8·2	2·6	8·0	16·2	19·0	17·9	15·3							
Organic carbon (%)	1·29	0·93	0·75					1·88	1·49					
Nitrogen (%)	0·12	0·08	0·08					0·16	0·08					
Available P_2O_5 (ppm)	92	24	26	16	18	24	16	36	16	32	22	12	28	36
Phosphorous P_2O_5 (%)	0·029	0·015	0·013	0·010	0·008	0·008	0·008							
Chloride as NaCl (%)	0·012	0·012	0·095	0·210	0·198	0·190	0·210	0·005	0·033	0·043	0·114	0·234	0·182	0·155
Specific conductivity (mhos x 10^{-3}) ..	0·056	0·057	0·440	1·008	0·928	0·960	0·960	0·04	0·10	0·14	0·73	1·04	0·93	0·75
Exchangeable cations:	A B	A B	A B	A B	A B	A B	A B	A B	A B	A B				
Calcium	8·0 62	5·0 32	11·1 40	12·0 32	9·6 31	9·1 37	7·4 35	10·3 62	11·5 54	10·5 41				
Magnesium	3·6 28	9·2 59	10·8 39	19·3 51	12·5 40	9·2 38	9·0 43	5·3 32	7·2 34	9·5 36				
Potassium	0·8 6	0·5 4	0·3 1	0·2 1	0·2 1	0·1 < ·5	0·1 1	0·7 4	0·2 1	0·2 1				
Sodium	0·5 4	0·9 5	5·5 20	6·4 16	8·9 28	6·1 25	4·5 21	0·4 2	2·3 11	5·6 22				
Total Metal ions	12·9 100	15·6 100	27·7 100	37·9 100	31·2 100	24·5 100	21·0 100	16·7 100	21·2 100	25·8 100				
Exch. Hydrogen	5·9		2·2				10·6							
Saturation (%)	69		93				66							
Exchange Capacity*	82		64				76							

A = mg. equiv./100 g. of soil. B = percentage composition of the exchangeable metal ions. * mg. equiv./100 g. clay.

APPENDIX II.—*continued.*

Mapping Unit.	Weakly Solonised Brown Clay Loam Association.					Weakly Solonised Brown Clay Loam Association.				Weakly Solodized-Solonetz Association.						
Great Soil Group.	Related to Grey and Brown Soils of Heavy Texture, Red-Brown Earths and Solodized-Solonetz.					Related to Grey and Brown Soils of Heavy Texture, Red-Brown Earths and Solodized-Solonetz.				Related to Grey and Brown Soils of Heavy Texture, Red-Brown Earths and Solodized-Solonetz.						
Location.	2 miles west of Billa Billa lagoons, north of Goondiwindi.					3½ miles south of Yagaburne Station, north of Goondiwindi.				1 mile south-east of the Southwood–Tara road crossing of the Moonie River.						
Lab. No.	1550	1551	1552	1553	1554	1535	1537	1538	1539	238	239	240	241	1491	1492	1493
Depth (in.)	0–3	3–4	4–12	12–22	22–36	0–2	6–12	12–24	24–36	0–2	2–12	12–22	22–36	36–48	48–60	60–70
Horizon	A_1	A_2	B_{21}	B_{22}	BC	A_1	B_{21}	B_{22}	BC	A_1	B_{21}	B_{22}	BC			
Texture	CL	CL	HC	MC	MC	CL	HC	MC	MC	CL	HC	HC	MC	MC	MC	MC
pH	7·0	7·3	8·3	8·3	8·2	6·5	7·2	7·6	6·3	6·7	5·8	7·5	7·6	5·4	5·0	4·8
$CaCO_3$ (%)	—	—	—	1·06	2·74	—	—	0·1		—	—					
Organic carbon (%)	1·59	0·53	0·70			1·0	0·67			1·41	1·03					
Nitrogen (%)	0·15	0·05	0·06			0·1	0·06			0·12	0·12					
Available P_2O_5 (%)	60	35	15	19	24	47	14	14	18	38	28	26	32	6	6	10
Chloride as NaCl (%)	—	—	0·008	0·045						0·025	0·117	0·140	0·124	0·112	0·107	0·104
Specific conductivity (mhos x 10^{-3})	0·108	0·053	0·157	0·471	0·983	0·045	0·416	0·576	0·463	0·09	0·64	0·73	0·63	0·59	0·53	0·57
Exchangeable cations :	A B	A B	A B			A B	A B			A B	A B					
Calcium	20·2 74	7·8 62	17·3 58			6·3 40	12·7 45			6·6 50	7·0 36					
Magnesium	5·7 21	4·0 32	10·2 34			8·0 52	12·0 42			5·4 41	9·4 48					
Potassium	1·0 4	0·2 1	0·3 1			0·6 4	0·4 2			0·4 4	0·1 1					
Sodium	0·3 1	0·6 5	2·1 7			0·6 4	3·1 11			0·7 5	3·0 15					
Total Metal ions	27·2 100	12·6 100	29·9 100			15·5 100	28·2 100			13·1 100	19·5 100					

A = mg. equiv./100 g. of soil. B = percentage composition of the exchangeable metal ions.

APPENDIX II.—*continued.*

Mapping Unit.	Weakly Solodized-Solonetz Association.					Weakly Solodized-Solonetz Association.					Red-Brown Earth Association.				
Great Soil Group.	Related to Grey and Brown Soils of Heavy Texture, Red-Brown Earths and Solodized-Solonetz.					Related to Grey and Brown Soils of Heavy Texture, Red-Brown Earths and Solodized-Solonetz.					Red-Brown Earth.				
Location.	¾ mile south of Toobeah.					1 mile east of Trevanna Downs station, north of Goondiwindi.					2 miles south-west of Coomoomie station, 14 miles S.S.W. of Glenmorgan.				
Lab. No.	1567	1568	1569	1570	1571	1540	1541	1542	1543	1544	1644	1645	1646	1647	1648
Depth (in.)	0–3	3–14	14–24	24–36	48–66	0–6	6–7	7–18	18–26	26–36	0–7	7–15	15–30	30–54	54–62
Horizon	A_1	B_{21}	B_{22}	B_{22}	BC	A_1	A_2	B_{21}	B_{22}	BC	A_1	B_{21}	B_{22}	BC	D
Texture	CL	HC	MC	MC	MC	SL	SL	SC	SC	SC	L–CL	MC	MC	MC	C
pH	6·2	7·4	7·8	8·0	7·7	5·3	6·0	6·2	8·3	8·9	7·1	8·3	8·5	7·2	5·0
$CaCO_3$ (%)	—	0·06	1·97	0·80	0·06	—	—	—	0·18	1·60	0·54	0·24	1·45	0·10	—
Mech. analysis (%)—															
Coarse sand	2·8	0·9			2 6										
Fine sand	46·7	23·9			17 2										
Silt	26·5	23·1			23·8										
Clay	21·0	45·1			50·8										
Loss on acid treatment	1·4	3·1			3·0										
Moisture	1·5	5·5			5·5										
Organic carbon (%)	1·20	1·02				0·69	0·60	0·42			1·82	0·75	0·75		
Nitrogen (%)	0·12	0·12				0·13	0·06	0·07			0·10	0·10	0·05		
Available P_2O_5 (ppm)	210	69	210	240	127	20	15	10	13	27	38	14	8	14	6
Chloride as NaCl (%)	0·007	0·088	0·215	0·198	0·223			0·012		0 049	0·008	0·078	0·202	0·161	0·099
Specific conductivity (mhos x 10^{-3})	0·073	0·559	1·970	1·189	0·662	0·023	0·037	0·148	0·434	0·543	0·058	0·410	1·152	0·832	0·496
Exchangeable cations :	A B	A B				A B	A B	A B			A B	A B	A B	A B	A B
Calcium	6·3 46	15·1 43				2·3 44	1·5 34	3·5 31			4·8 38	7·3 29	16·6 58	2·5 14	0·3 4
Magnesium	5·9 44	14·5 41				2·4 46	2·4 54	5·3 47			6·4 49	14·5 58	9 4 33	12·8 70	5·3 71
Potassium	0·6 4	0·3 1				0·3 6	0·2 4	0·2 2			0·8 6	0·3 1	0·5 2	0·2 1	0·2 2
Sodium	0·9 6	5·3 15				0·2 4	0·4 8	2·3 20			0·9 7	2·9 12	1·9 7	2·6 15	1·8 23
Total Metal ions	13·7 100	35·2 100				5·2 100	4·5 100	11·3 100			12·9 100	25·0 100	28·4 100	18·1 100	7·6 100
Exch. Hydrogen	4·5							6·2							7·1
Saturation (%)	75							64							51
Exchange Capacity*	84														

A = mg. equiv./100 g. of soil. B = percentage composition of the exchangeable metal ions. * mg. equiv./100 g. clay.

APPENDIX II.—*continued.*

Mapping Unit.	Red-Brown Earth Association.			Lateritic Red Earth Association.			Lateritic Red Earth Association.			Deep Sands Association.					
Great Soil Group.	Red-Brown Earth.			Lateritic Red Earth.			Lateritic Red Earth.			Regosol.					
Location.	3 miles north of Springmount turnoff, Bungunya–Surat road.			Near Lienassee Station. 4 miles south of the Moonie highway.			1 mile west of Wybar Station, 30 miles north of Goondiwindi.			1½ miles west of the Weir River, Goondiwindi–Lundavra road.					
Lab. No.	1555	1556	1557	225	226	227	2155	2156	2157	232	233	234	235	236	237
Depth (in.)	0–10	10–26	26–36	0–8	8–24	24–36	0–8	8–24	24–36	0–12	12–24	24–36	36–48	48–60	60–72
Horizon	A_1	B_{21}	B_{22}	A_1	B_{21}	B_{22}	A_1	B_{21}	B_{22}	1	2	3	4	5	6
Texture	L–CL	LC	MC	L–CL	CL–LC	LC	L–CL	CL–LC	LC	S	S	S	S	S	S
pH	6·9	8·1	8·2	5·4	5·2	6·6	4·6	5·0	5·6	6·8	6·8	8·3	8·3	7·7	7·5
$CaCO_3$ (%)	—	0·16	0·55	—	—	—	—	—	—						
Organic carbon (%)	1·24			1·02	0·42		0·97	0·55		0·16	0·13				
Nitrogen (%)	0·11			0·07	0·08		0·07	0·05		0·04	0·06				
Available P_2O_5 (ppm)	260	38	38	22	24	16	20	14	10	52	38	52	22	20	26
Chloride as NaCl (%)				0·002	0·004	0·004						tr.	tr.		
Specific conductivity (mhos x 10^{-3}) ..	0·084	0·158	0·549	0·05	0·03	0·06	0·040	0·059	0·071	0·003	0·002	0·097	0·070	0·002	0·001
Exchangeable cations :	A B	A B		A B	A B		A B	A B		A B	A B				
Calcium	9·8 48	10·6 37		3·8 68	2·0 74		2·3 53	4·0 51		1·7 45	1·0 38				
Magnesium	6·3 31	12·8 45		1·2 21	0·4 15		1·7 40	3·5 45		2·0 53	1·5 58				
Potassium	3·6 17	2·6 10		0·5 9	0·1 4		0·2 2	0·1 3		0·08 2	0·06 3				
Sodium	0·7 4	2·4 8		0·1 2	0·2 7		0·1 5	0·2 1		0·03 <1	0·03 1				
Total Metal ions	20·4 100	28·4 100		5·6 100	2·7 100		4·3 100	7·8 100		3·8 100	2·6 100				

A = mg. equiv./100 g. of soil. B = percentage composition of the exchangeable metal ions.

APPENDIX II.—*continued.*

Mapping Unit.	Sandy Solod, Solodic, Solodized-Solonetz Association.										Sandy Solodic Association.				
Great Soil Group.	Solod.				Solod.						Solodic.				
Location.	8½ miles E.N.E. of Yelarbon.				Weir Highway, 6 miles south of Moonie Highway.						1 mile east of Westmar, Moonie Highway.				
Lab. No.	253	254	255	256	1494	1495	1496	1497	1498	1499	1483	1484	1485	1486	1487
Depth (in.)	0–6	6–22	22–30	30–48	0–12	12–24	24–36	36–46	46–54	54–60	0–15	15–18	18–26	26–36	36–50
Horizon	A_1	A_{21}	A_{22}	B_2	A_1	A_2	A_2	A_2	A_2	B_2	A_1	A_2	B_{21}	B_{22}	BC
Texture	S	S	LS	SCL	S	S	S	S	S	CS	LS	S	MC	MC	SC
pH	5·1	5·0	5·3	5·6	6·4	6·5	5·5	6·0	5·8	5·9	5·3	7·5	7·5	8·3	8·5
Organic carbon (%)	0·88	0·15													
Nitrogen (%)	0·10	0·07													
Available P_2O_5 (ppm)	22	26	16	20	40	26	22	12	12		30	26	20	18	18
Chloride as NaCl (%)	—	—	—	0·005	—	—	—	—	—	0·005	—	0·010	0·041	0·060	0·066
Specific conductivity (mhos x 10^{-3})	0·009	0·014	0·012	0·009	0·02	0·01	0·007	0·009	0·01	0·04	0·02	0·04	0·19	0·30	0·31
Exchangeable cations:	A B	A B		A B						A B			A B		
Calcium	1·0 49	0·5 43		0·3 8						0·2 4			2·7 19		
Magnesium	1·0 48	0·6 56		2·8 80						3·5 73			8·8 61		
Potassium	0·1 3	tr. <1		tr. <1						0·2 4			0·3 2		
Sodium	tr.	tr. <1		0·4 11						0·9 19			2·5 18		
Total Metal ions	2·1 100	1·1 100		3·5 100						4·8 100			14·3 100		
Exch. Hydrogen				6·3						4·7			3·1		
Saturation (%)				36						51			82		

A = mg. equiv./100 g. of soil. B = percentage composition of the exchangeable metal ions.

APPENDIX II.—*continued.*

Mapping Unit. Great Soil Group.	Sandy Solodized-Solonetz Association. Solodized-Solonetz.				Solodized-Solonetz Association. Solodized-Solonetz.				Solodized-Solonetz Association. Solodized-Solonetz.							
Location.	12 miles west of Millmerran.				10 miles south of Boondandilla station.				Beebo–Magee road junction south of Inglewood.							
Lab. No.	2151	2152	2153	2154	2158	2159	2160	2161	218	219	220	221	1523	1524	1525	1526
Depth (in.)	0–4	4–7	7–18	18–33	0–6	6–10	10–18	18–33	0–6	6–10	10–15	15–30	30–36	36–48	48–54	54–60
Horizon	A_1	A_2	B_{21}	B_{22}	A_1	A_2	B_{21}	B_{22}	A_1	A_2	B_{21}	B_{22}	BC	BC	C	C
Texture	S	S	SC	SC	L	CL	M–HC	MC	CL	CL	HC	MC	MC	MC	LC	C (gr.)
pH	5·5	5·8	7·3	8·2	5·7	5·4	6·0	7·7	5·4	6·3	6·8	7·8	7·4	6·7	6·4	6·9
$CaCO_3$ (%)	—	—	—	0·08	—	—	—	0·04	—	—	—	—	—			
Organic carbon (%)	1·36	0·54			1·37	0·45			2·00	0·44						
Nitrogen (%)	0·14	0·09			0·08	0 02			0·06	0·06						
Available P_2O_5 (ppm)	20	12	10	24	14	18	16	12	26	14	16	16	12	12	16	6
Chloride as NaCl (%)	0·006	0·003	0·036	0 054	—	—	0·013	0·099	0·008	0·008	0·040	0·070	0 048	0·102	0·050	0·041
Specific conductivity (mhos x 10^{-3})	0·036	0·030	0·094	0 120	0·043	0·025	0·164	0·343	0·04	0·03	0·23	0·32	0·33	0·50	0·32	0·25
Exchangeable cations:	A B	A B	A B	A B	A B	A B	A B	A B	A B	A B	A B	A B				
Calcium	1·8 45	1·0 36	1 5 12	1·2 8	2·0 37	0 3 12	1·2 13	1·5 10	0·8 32	1·3 43	1·0 6	0·8 3				
Magnesium	1·9 47	1·5 54	6 2 50	8·6 55	2 7 51	1·9 78	5·3 58	9·5 64	1·2 51	1·4 46	10·4 67	15·3 66				
Potassium	0·1 2	tr. —	0·1 1	0·2 1	0·3 6	tr. 1	0·1 1	0·1 1	0 2 7	tr. 1	0·1 1	0·1 1				
Sodium	0·3 6	0·3 10	4·6 37	5·6 36	0·4 6	0·2 9	2·5 28	3·8 25	0·2 10	0·3 10	4·0 26	6·9 30				
Total Metal ions	4·1 100	2·8 100	12·4 100	15·6 100	5·4 100	2 4 100	9·1 100	14·9 100	2·4 100	3·0 100	15·5 100	23·1 100				
Exch. Hydrogen	5·6		3·3						11·6			1·6				
Saturation (%)	42		79						17			93				

A = mg. equiv./100 g. of soil. B = percentage composition of the exchangeable metal ions.

Mapping Unit.	Stony Solodized-Solonetz Association.						
Great Soil Group.	Solodized-Solonetz.						
Location.	Beebo road crossing of Brush Creek, south of Inglewood.						
Lab. No.	213	214	215	216	217	1521	1522
Depth (in.)	[illegible]	3–4	4–10	10–24	24–36	36–48	48–60
Horizon	A_1	A_2	B_{21}	B_{22}	B_{22}	B_{22}	BC
Texture	CL	CL	HC	MC	MC	MC	SC
pH	6·0	7·0	8·3	8·6	8·8	7·8	8·8
Free Carbonates (as % CO_2) ..	—	—	—	—	—		
Mech. analysis (%)—							
Coarse sand							
Fine sand							
Silt							
Clay							
Moisture							
Organic carbon (%)	0·46	0·53	0·68				
Nitrogen (%)	0·08	0·06	0·10				
Available P_2O_5 (ppm)	36	16	32	22	12	28	36
Chloride as NaCl (%)	0·007	0·007	0·030	0·048	0·045	0·045	0·026
Specific conductivity (mhos x 10^{-3})	0·01	0·03	0·34	0 39	0·25	0·20	0·08
Exchangeable cations :	A B	A B	A B	A B	A B		
Calcium	1·0 37	0·8 18	1·0 5	0·3 1	0·3 1		
Magnesium	1·3 48	2·8 65	13·8 70	20·9 68	17·8 65		
Potassium	0·1 3	0·1 3	0·1 1	0·1 <1	0·1 <1		
Sodium	0·3 12	0·6 14	4·7 24	9·4 31	9·3 34		
Total Metal ions	2·7 100	4·3 100	19·6 100	30·7 100	27·5 100		
Exch. Hydrogen			2·5				
Saturation (%)			89				

Mapping Unit.	Solonetz-Solodized-Solonetz Association.						
Great Soil Group.	Solonetz.						
Location.	3 miles south-east of Yelarbon.						
Lab. No.	1500	1501	1502	1503	1504	1505	1506
Depth (in.)	0–4	4–10	10–18	18–36	36–48	48–60	60–70
Horizon	A_1	A_2	B_{21}	B_{22}	BC	C	C
Texture	CL	CL	MC	MC	C	C	C (sl. S)
pH	8·1	9·3	10·2	10·2	10·1	10·1	10·1
Free Carbonates (as % CO_2) ..	—	—	0·7	0·4			
Mech. analysis (%)—							
Coarse sand	1·7	6·7		13·0			
Fine sand	34·6	15·4		14·3			
Silt	37·3	45·7		32·1			
Clay	17·5	29·7		36·8			
Moisture	1·6	1·9		4·5			
Organic carbon (%)	0·85	0·62					
Nitrogen (%)	0·07	0·03					
Available P_2O_5 (ppm)	32	16	84	264	170	128	114
Chloride as NaCl (%)	0 020	0·043	0·043	0·071	0·070	0·070	0·066
Specific conductivity (mhos x 10^{-3})	0·09	0·18	0·52	0·80	0·59	0·57	0·55
Exchangeable cations :	A B	A B	A B	A B			
Calcium	2·7 26	1·5 11	19·0 42	13·8 35			
Magnesium	6·0 58	7·5 54	10·2 23	7·3 18			
Potassium	0·2 2	0·4 2	0·4 1	0·4 1			
Sodium	1·4 14	4·6 33	15·3 34	18·3 46			
Total Metal ions	10·3 100	14·0 100	44·9 100	39·8 100			
Exch. Hydrogen							
Saturation (%)							

A = mg. equiv./100 g. of soil.   B = percentage composition of the exchangeable metal ions.

A. H. Tucker, Government Printer, Brisbane.