STUDY OF THE LAND, IN NORTH WESTERN VICTORIA

By J. N. Rowan and B. G. Downes

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SUMMARY

A survey has been made of 14,140 square miles in north-western Victoria to provide information about the various natural environments and their significance for land use. About two-thirds of the area has been settled, and the predominant form of land use is alternate cropping and grazing.

The climate is semi-arid, the average annual rainfall varying from 14 inches in the southern part to 10 inches in the northern part of the area. The winters are mild and the summers are hot. The rainfall distribution shows a winter maximum so that crop and pasture growth tends to be seasonal because of the inadequacy of moisture during the summer.

The area is a vast plain on which there are superficial undulations among which dunes, jumbled dunes, hummocks and ridges are the most widespread. Surface materials are of aeolian origin, ranging in texture from sands to clays. They are layered, having been deposited in a series of and periods during relatively recent geological times.

The soils have been classified primarily according to their surface texture which, in this region, is the most significant soil feature affecting land-use.

The native vegetation includes a wide range of communities, but of these mallee (multi-stemmed eucalypts) is by far the most widespread.

The area has been mapped into 13 land systems. Within each the array of land forms, soils, native vegetation, climate and land-use features is described. In particular the problem of wind erosion is discussed-the hazard, the incidence and, the pattern of conservation farming required to prevent its occurrence.

A STUDY OF THE LAND IN NORTH-WESTERN VICTORIA

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I. INTRODUCTION

White man first occupied north-western Victoria in the 1840's when pastoralists, took up land along the River Murray, and also at Pine Plains near Patchewollock, at Lake Coorong near Hopetoun and at Tyrrell Downs beside Lake Tyrrell. Cow Plains in the Cowangie district was taken up in 1860. These areas were chosen for grazing because, unlike the surrounding country, they provided a good proportion of grassland and a water supply.

Agricultural settlement began in the 1880's in the southern-most parts of the region, spreading to the centre by about 1912 and to the north in the 1920's. About 65 per cent of the country has been occupied, the remainder being mainly inferior, sandy country in the western parts. Agricultural settlement required the rolling and burning of the native timber and also the provision of water for stock and domestic use. The water is reticulated by channel, mainly from the Grampians catchments, to the south, but also from the Goulburn river system to the east. Channels are not needed in the south-western and central-western parts of the region where bores supply good quality water.

Intensive cereal production followed settlement. Wind erosion began on a vast scale because of a lack of understanding of the environment (Plate 1). Neither the settlers nor the Government were familiar with the development of land in such a dry climate, and the application of methods used in higher rainfall country, such as the preparation of finely-worked bare fallows, soon led to widespread erosion. Although a more stable system of farming has gradually developed, with emphasis on mixed farming (Table 1) rather than intensive cereal production, erosion still occurs widely.

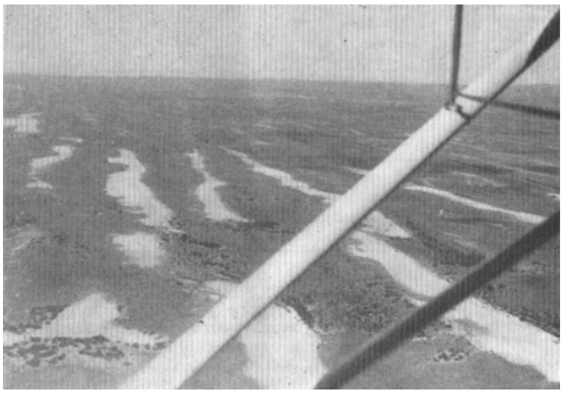


Plate 1 - Aerial photograph of badly eroded east-west trending dunes at Piangil West in the Central Mallee system.
The farm has been neglected and much of it is reverting to scrub.

Table 1 – Rural statistics (1960-61) for the Shires of Mildura, Walpeup and Karkarooc. (Data from "Victorian Rural Statistics, Season 1960-61", prepared by the Commonwealth Bureau of Census and Statistics).

Shire		Mildura	Walpeup	Karkarooc
Areas in acres	Total occupied	2,153,143	1,460,135	801,534
	Crop	179,263	300,772	298,658
	Fallow	58,351	164,512	177,666
	Sown pasture	36,185	173,421	81,021
	Native pasture	1,478,945	607,758	206,118
	Wheat for grain	116,370	194,880	211,487
	Oats for grain	17,626	48,266	36,945
	Barley for grain (two-row)	4,208	31,703	38,474
	Cereal rye for grain	1,345	16,451	1,707
	Hay (cereal and pasture)	3,601	9,624	12,292
Production in bushels	Wheat	2,263,980	3,833,805	4,567,742
	Oats	258,406	728,055	729,078
	Barley	74,412	608,996	813,119
	Cereal rye	9,849	126,936	12,144
Livestock numbers	Sheep and lambs	214,960	307,122	263,431
	Beef cattle	3,240	2,568	1,104
	Dairy cattle	2,933	1,850	2,088
	Pigs	1,307	1,695	2,446
Acres per sheep		10.0	4.8	3.0

NOTE. These statistics characterize, with varying degrees of accuracy, some of the land systems. The settled parts of the Mildura Shire correspond fairly well with the Millewa land system. Similarly, the cleared parts of the Walpeup Shire embrace mainly the western parts of the Central Mallee land system. The Karkarooc Shire comprises mainly the western parts of the Hopetoun land system but also the Tempy land system.

Wind is by far the most destructive agent of erosion in the area. The soils on rising ground are very permeable and thus they suffer only minor water erosion on those occasions when heavy cloudbursts fall on bare fallows. Severe water erosion is confined to slopes which have previously been wind eroded to expose raw subsoils of low permeability, for example cemented dune cores or scalded clays on lunettes (Plate 2). The general absence of a drainage pattern on rising ground is evidence of the low water erosion hazard.

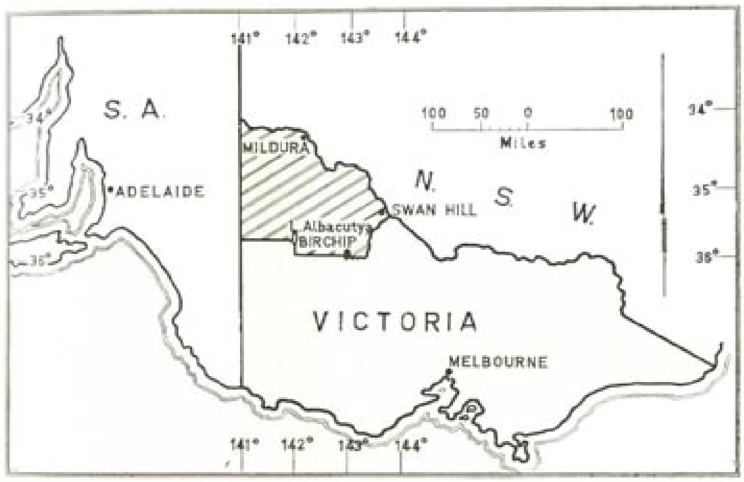


Fig. 1. Locality Plan

Irrigation from the River Murray began in the late 1880's at Mildura. Although it has expanded into several riverside settlements, the total acreage is small compared with the dry-land farming areas. Vines are the chief crop under irrigation.

Figure 1 shows the location of the area surveyed which covers 14,140 square miles or approximately 16 per cent of the State of Victoria. The Counties involved are Millewa, Karkarooc, most of Weeah and more than half of Tatchera, embracing the Shires of Mildura, Walpeup, Karkarooc, most of Birchip, Wycheproof and Swan Hill, part of Dimboola and a small portion of Kerang.

II. CLIMATE

The north-western part of Victoria is semi-arid. The summers are hot and mainly dry whilst the winters are mild and usually moist, so that agriculture is based on annual cereals and pastures which are grown during the cooler and wetter part of the year. Thus the climate is similar to the Mediterranean type. However, it differs from the typical Mediterranean climate in that significant falls of summer rain sometimes occur.

The average annual rainfall decreases from 14 inches in the south to 10 inches in the north. Isohyets, at one inch intervals are shown on the map of the land systems. One inch represents from 7 to 10 per cent of the average annual total, and from field observation over a number of years, a difference in average annual rainfall of one inch is significant for agriculture. The isohyets have been drawn as lines of "best fit", based on data supplied by the Commonwealth Bureau of Meteorology for 74 recording stations. Calculations were based on readings taken since the inception of records to 1957.

The rainfall is not only low but it is also unreliable. At Ouyen (Table 2) the yearly total has varied from 5-78 to 20-33 inches whilst the monthly totals: also show wide variation, for example January has ranged from nil to 437 points. The unreliability of the rainfall is also shown by the percentage variability* of 26 per cent at Mildura, 23 per cent at Swan Hill and 21 per cent at Wycheproof. These values indicate that the variability becomes greater from south to north.

The rainfall distribution throughout the year at selected stations is listed in Table 3 and graphed in Figure 2. On the average the wettest months are from May to October. At Ouyen these six cooler months receive 60 per cent of the yearly total. There is a minor peak in the rainfall curves in February and rains in this month are relatively heavy as shown by the rainfall per wet day which, at Rainbow for example, is 37 points compared with the yearly average of 19 points.

The temperature data in Table 4 show that summers are hot and winters mild. Throughout the year temperatures are a little higher in the north than in the south. Above century temperatures are common during the summer and there are normally several frosts each year during the cooler months.

Temperate zone plants cease growth when temperatures fall below approximately 41°F and their optimum growth rate occurs at about 80°F. Table 4 shows that the average winter maximum temperature of about 60°F allows considerable growth of crops and pastures and that the optimum temperatures for growth occur mainly in the early autumn and late spring.
Potential evaporation is high, ranging from about 60 inches per annum in the north to 50 inches in the south (Central Planning Authority 1952). Monthly potential evaporation ranges from about 10 inches in summer to 111 inches in winter.

* $\text{Percentage variability} = \dfrac{\text{average deviation from mean annual rainfall}}{\text{mean annual rainfall}} \times 100$

There are normally several days per year on which winds of gale force blow and field observation suggests that it is on these, days that most wind erosion occurs. Gales are mainly from the west, south-west or north-west so that the general direction of soil drifting is from west to east.

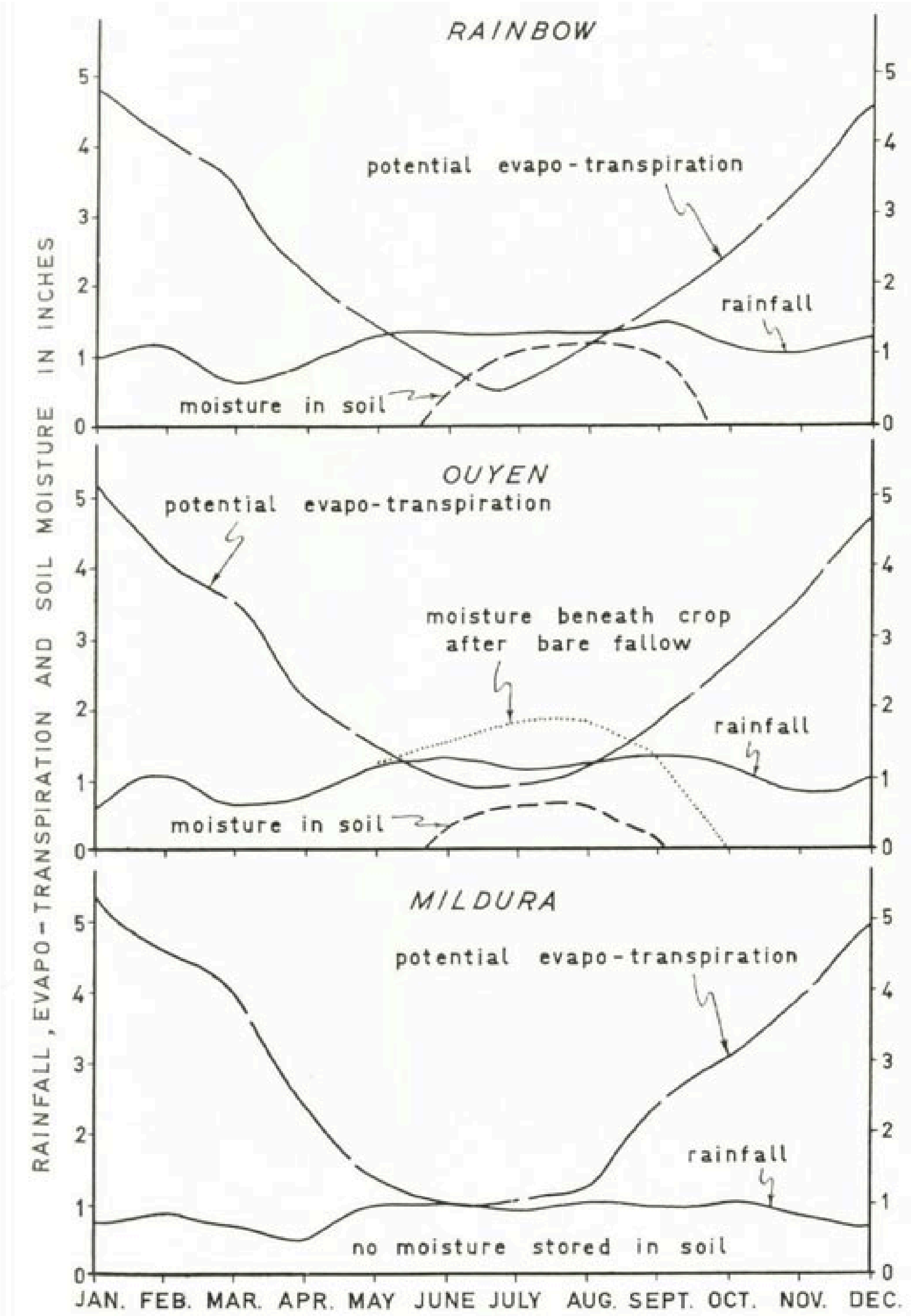


Fig 2 – Relationship between rainfall and potential evapo-transpiration

Table 2. - Monthly and Annual Rainfall at Ouyen (in points)

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Totals
1913	0	52	312	131	135	0	0	52	234	250	48	103	1,317
1914	10	62	108	161	56	10	35	0	3	0	80	111	636
1915	59	0	0	37	133	157	164	113	365	54	21	0	1,103
1916	59	0	14	26	101	273	133	240	322	159	262	50	1,639
1917	39	328	88	0	149	162	165	340	263	285	214	0	2,033
1918	57	46	117	124	417	93	73	178	34	90	21	0	1,250
1919	0	231	62	40	188	92	46	35	54	19	61	217	1,045
1920	6	0	24	27	80	110	170	311	320	319	82	99	1.548
1921	199	178	194	0	150	171	96	142	245	70	85	88	1,618
1922	45	94	3	104	138	96	122	96	127	94	0	148	1,067
1923	34	0	0	37	174	447	289	114	92	110	31	105	1,433
1924	86	171	123	14	51	126	9	143	173	115	245	135	1,391
1925	73	75	62	8	204	78	124	107	137	19	55	0	942
1926	10	0	31	191	292	76	132	138	164	61	1	106	1,202
1927	49	23	23	0	69	32	148	70	70	106	37	17	644
1928	45	235	71	150	56	154	107	25	87	119	0	23	1,072
1929	12	94	13	85	37	90	34	72	45	14	77	275	848
1930	0	4	52	20	262	16	101	143	64	340	63	124	1,189
1931	21	0	183	332	147	294	86	45	179	76	52	0	1,415
1932	8	212	137	132	116	281	92	204	48	44	4	83	1,361
1933	144	0	10	49	123	14	194	122	156	84	81	638	1,615
1934	5	94	45	169	0	22	100	69	101	349	212	64	1,230
1935	47	11	64	58	45	104	120	76	129	231	7	68	960
1936	409	0	20	108	40	174	335	79	7	142	15	97	1,426
1937	139	6	70	7	85	170	73	268	37	194	23	191	1,263
1938	144	54	0	57	10	51	156	85	6	11	2	2	578
1939	66	393	13	179	126	168	48	178	49	43	237	0	1,500
1940	42	17	0	139	14	15	85	34	173	17	78	72	686
1941	437	14	57	15	12	170	152	39	156	193	154	58	1,457
1942	44	15	11	109	215	208	128	206	75	208	109	22	1,350
1943	42	36	10	61	20	86	101	156	85	107	79	106	889
1944	38	18	14	49	175	5	67	17	40	103	88	110	724
1945	5	35	6	0	59	225	73	173	49	124	76	55	880
1946	231	270	159	17	102	125	129	119	50	49	117	54	1,422
1947	0	265	226	70	24	114	169	118	88	180	184	222	1,660
1948	22	5	5	143	120	184	83	57	32	376	183	97	1,307
1949	50	166	44	9	365	34	126	36	143	534	152	8	1,667

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Totals
1950	0	425	404	37	159	53	121	73	125	115	127	61	1,700
1951	31	65	27	65	111	221	146	177	45	169	26	27	1,110
1952	108	76	145	102	237	135	47	100	88	284	301	39	1,662
1953	122	80	0	48	51	221	168	191	250	115	171	35	1,452
1954	90	7	10	234	70	57	90	220	82	173	105	289	1,427
1955	0	179	119	38	212	274	152	190	224	73	104	44	1,609
1956	39	0	263	184	409	136	264	125	170	279	82	4	1,955
1957	0	269	90	27	39	133	103	86	21	42	53	80	943
1958	174	151	7	47	155	19	187	275	89	423	155	78	1,760
Averages	70	97	75	79	129	128	120	127	119	151	95	91	1,282

Table 3 – Rainfall distribution throughout the year at selected stations

		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Mildura	Average rainfall (points)	68	82	76	63	108	118	92	106	93	112	82	70	1,076
69 years	Number of wet days	3	2	3	4	5	8	7	8	6	5	4	3	58
1890-1958	Average rainfal per wet day (point)	23	41	25	16	22	15	13	13	16	22	20	23	19
	Percentage frequency of occurrence of rainfall equal to or greather than the effective amount*	5	10	10	12	35	63	53	53	21	20	10	4	
Ouyen	Average rainfall (points)	70	97	75	79	129	128	120	127	119	151	95	91	1,281
46 years	Number of wet days	3	3	3	4	7	8	9	9	6	7	5	3	66
1913-1958	Average rainfall per wet day (point)	23	32	25	20	18	16	14	14	20	22	19	30	19
	Percentage frequency of occurrence of rainfall equal to or greater than the effective amount	7	14	7	23	48	66	69	64	44	29	12	8	
Rainbow	Average rainfall (points)	68	111	77	81	151	150	142	138	146	138	97	91	1,408
(Pella)	Number of wet days	3	3	3	4	8	9	10	10	9	8	5	3	76
57 years	Average rainfall per wet day (points)	23	37	26	20	19	13	14	14	16	17	19	31	19
1902-1958	Percentage frequency of occurrence of rainfall equal to or greater than the effective amount	9	16	11	30	63	80	86	74	60	35	19	13	

* Based on Prescott’s concept that effective rainfall occurs in any month when $\frac{P}{E^{0.75}}$ is greater than 0.54, where P is the monthly rainfall in inches and E is monthly evaporation in inches from an Australian standard evaporation tank.

Table 4 – Average maximum and minimum temperatures, °F

Recording station and location within Region	Summer (Dec Jan Feb)		Autumn (March April May)		Winter (June July Aug)		Spring (Sept Oct Nov)	
	Max	Min	Max	Min	Max	Min	Max	Min
Mildura (north)	89	61	75	51	61	41	77	51
Swan Hill (centre)	88	59	74	49	59	40	75	48
Birchip (south)	86	56	73	48	58	39	73	46

A study of the combined effects of rainfall and evapo-transpiration gives a better understanding of the availability of moisture for plant growth than an examination of rainfall records alone. Leeper (1950) has proposed a formula* to calculate monthly potential evapo-transpiration from temperature records and if this is compared with monthly rainfall it will indicate whether the moisture received is sufficient for plant growth. This has been done in Figure 2 for three stations representative of the south (Rainbow), center (Ouyen) and north (Mildura). The graphs are based on 30 year averages for the period 1911-40 and they agree well with field observation.

The growing period is the time during which the rainfall and the ability of the soil to supply stored moisture together exceed evapo-transpiration. Figure, 2 shows that this period is limited, on the average,, to three winter months at Ouyen. The closeness of the two curves during the growing period indicates that the build-up of soil moisture under crops and pastures is only slight (less than 20 points at Ouyen). Because of this slight build-up and the fact that the rain usually comes as isolated falls at irregular intervals there is a fluctuation between periods of adequate and insufficient moisture even during th6 growing season. The shortness of the growing period and its unreliable moisture supply severely limit agricultural productivity at Ouyen.

Sims and Mann (unpublished data) have shown that bare fallows near Ouyen stored, to a depth of 36 inches, an average of 11 inches of rain per year more than non-fallows over a trial period of eight years. This amount of rain has been added to the May rainfall at Ouyen in Figure 2 to indicate the effect of fallowing on the moisture supply to subsequent crops. It can be seen that crops on previously fallowed. land are supplied, on the average, with adequate moisture until mid-October i.e. some six weeks longer than crops without fallow. In spite of , this extension of the growing season until mid-October, crop yields after fallow are still limited in an average season by lack of moisture during the late spring. Good rains are needed in October and November to produce heavy crops.

From Figure 2 it can also be seen that, compared with Ouyen, moisture supply during the growing period is more favourable at Rainbow in the south and less favourable at Mildura in the north. The average annual rainfall during the period on which Figure 2 is based is 13.6 inches at Rainbow, 12.4 inches at Ouyen and 10.4 inches at Mildura. This indicates that the accepted practice of using average annual rainfall as a climatic index within the region is sound.

Being based on average monthly data, Figure 2 does not show the value of rain outside the growing period, particularly for a perennial such as lucerne which responds well to autumn, spring and summer rains.

Data from an alternative method of determining the effectiveness of rainfall have been presented by the Central Planning Authority (1952). Monthly values from this source have been included in Table 3 as the percentage frequency of occurrence of rainfall equal to or greater than the effective amount at Mildura, Ouyen and Rainbow. These data confirm the above interpretations based on the formula proposed by Leeper. It can be seen that a growing period occurs during the cooler months and that, even during this period, there are times of inadequate moisture supply. In addition a trend is shown from a better moisture supply in the south to a less favourable supply in the north. For example, the chances of receiving rainfall sufficient to be effective during July are 86 per cent. at Rainbow, 69 per cent at Ouyen and only 53 per cent at Mildura.

Plate 2 – Aerial photograph of water erosion on lunettes near Tiega in the Tyrell Creek land system, looking north-east.

* Monthly Et = 4.4 S + (T-m) where evapo-transpiration Et is measured in millimetres, S is the saturated vapour pressure at the temperature T of the particular month and m is the annual mean temperature, both T and m being measured in Farenheit.

III. GEOLOGY ANB PHYSIOGRAPHY

North-western Victoria is a vast plain on which there are superficial undulations. The general elevations are 300 to 350 feet above sea level in the south, falling gently to between 150 and 200 feet in the center and north. There is no drainage pattern apart from the, River Murray system along the eastern and northern boundary and occasional effluents, such as the Tyrrell, Lalbert, Yarriambiack and Outlet Creeks, which enter from the south. These creeks are usually dry and their courses end in the central parts of the region in basins, most of which contain salt and gypsum.

Most geological information has been obtained from the logs of bores put down in search of fresh water (Hills 1939 and Gloe 1947). Since early Tertiary times there has been an accumulation of aeolian, fresh water and marine deposits. The surface materials are almost entirely of aeolian origin and they range in texture from sands to clays, as discussed under parent materials in the soils section. They are underlain by Pleistocene and Late Tertiary aeolian and fresh water strata which average some 200 feet in thickness in County Weeah (see Figures 3 and 4). At still greater depth, marine deposits are' encountered, including limestones which contain the fresh water sought by boring.

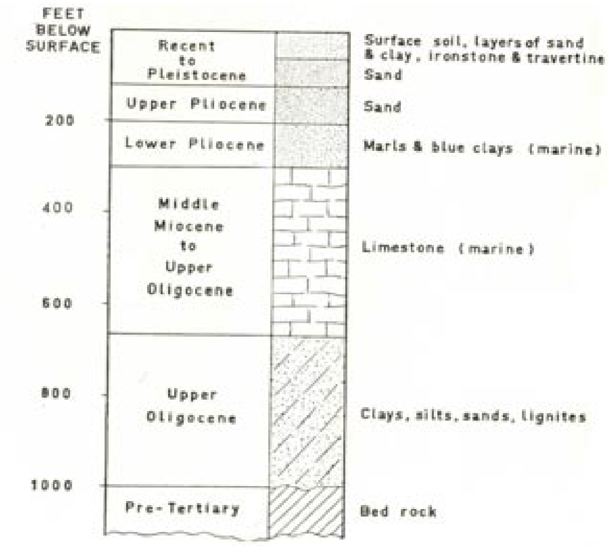


Fig 3 – Generalized section of a Mallee Bore.
(from G. S. Gloe 1947)

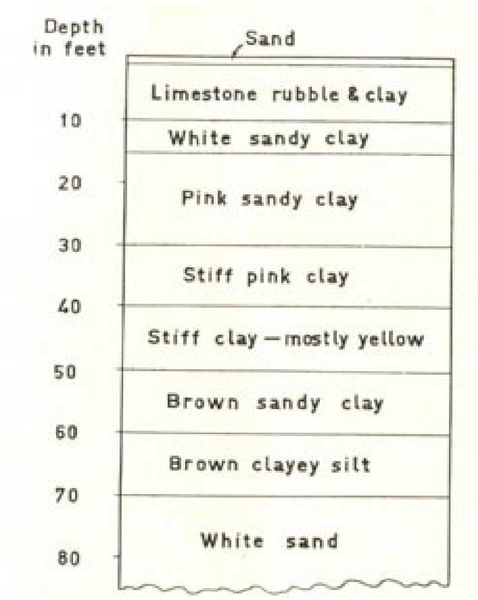


Fig 4 – Section through strata at Murrayville to a depth of 80 feet
(Courtesy of F. N Bethune)

There is evidence that lateritisation, a process usually associated with high rainfall, has occurred in the past. Red and white coarsely-mottled clays have been noted in the cliffs beside the Robinvale lock, within a few feet of the surface at Brighton's Tanks, 7 miles north-west of Nowingi, and about 40 feet below the surface of allotment 42, Parish of Kattyoong, north of Walpeup. Ironstone is scattered on the surface of many areas, particularly towards the south. In places this ironstone appears to be associated with a laterite profile, for example half a mile east of Lascelles it is underlain by a sandy clay which resembles mottled and pallid zones. Butler and Hutton (1956) report a similar occurrence at Tittybong, to the south-east of Swan Hill. Hard siliceous rocks occur at Rock Holes in the extreme south-western corner of County Millewa. Northcote (1951) has recorded similar rocks in adjacent parts of South Australia and he considered them to be remnants of the lower part of a laterite formation.

Four main undulating land forms have been recognized within the area, namely the *dune, jumbled dune, ridge* and *hummock.* The *lunette* and the *copi island* also occur, but to a limited extent. These superficial undulations are of aeolian origin. Melton (1940) has shown that many factors govern the shape of aeolian land forms, including the strength, duration and orientation of the wind, the erodibility and depth of the soils, the presence or absence of obstructions and the nature of the vegetation. Because of the complexity it is not surprising that there has been little investigation to determine the mode of formation of the various types of undulations.

To indicate the nature of the landscape, the distribution of land forms. along the railway line between Ouyen and the South Australian border is shown in Figure 5. The undulations are hummocks and ridges. Although widespread in the district, dunes do not show up in the section because they are elongated in an east-west direction and the railway line runs between them. The low, flat section to the east of Cowangie is an internal drainage basin.

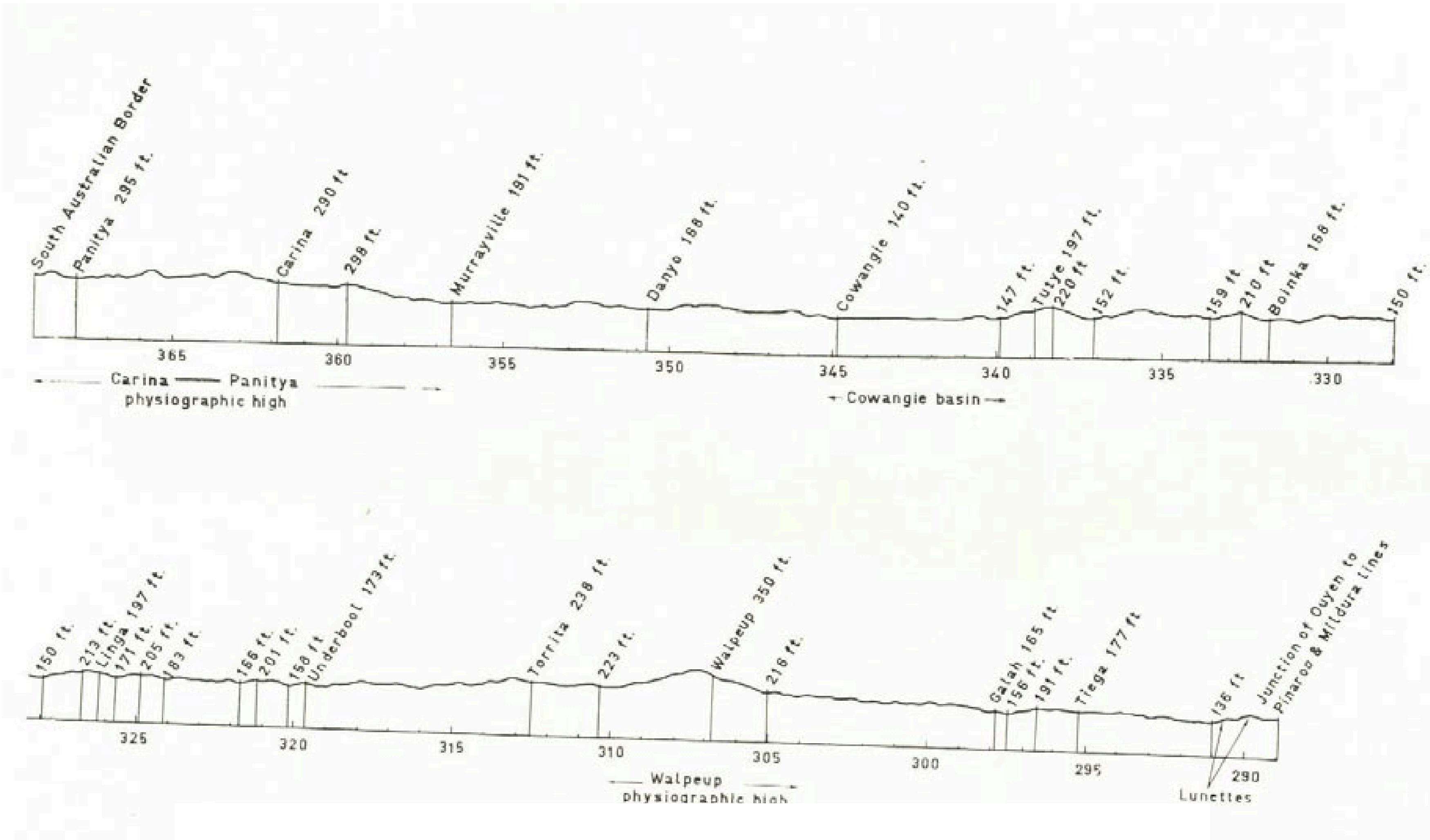
Dune The dune lies east-west, forming a striking landscape feature (plates 1, 15, 16, 17). Most dunes are between 4 and 6 chains wide, 10 and 30 feet high and from 1 to 2 miles long. They occur throughout the region except in the south-east. The surface is smoothly curved in its undisturbed state. The materials consist of loose sand overlying a compact core of somewhat heavier texture. Dunes in the Big Desert and Berrook land systems are exceptions in having only weakly compacted cores and sharp crests known as "razorbacks".

East-west dunes occur in adjacent parts of South Australia and New South Wales whilst dunes of variable orientation occupy a considerable proportion of the arid interior of the continent. It is generally accepted that the dunes are parallel to the causal wind direction. King (1960) has suggested that they are built up by erosion of the interdune corridors rather than by advancement from a sand source. This is supported by field evidence in north-western Victoria where dunes occur on relatively sandy source areas, with very limited eastward movement.

Jumbled Dune This dune is also elongated, but it is sharply curved, as shown in Plate 19. The average dimensions are greater than those of the east-west trending dune, and impressive razorbacked prominences over 100-ft. high are common. The texture is sand throughout, with little compaction at depth.

Within the region, jumbled dunes are confined to the Big Desert and Beffook land systems in the west. However, similar dunes occur further to the west and south-west in the Ninety-mile Plain of South Australia, and to the south in the Kowree and Little Desert land systems (Blackburn and Gibbons 1956), and in the Kanawinka and Follett land systems of south-western Victoria (Gibbons and Downes in press). The limitation of jumbled dunes to these areas appears to be related to the copious supplies of sand available for their formation.

Fig 5 – Cross section of country between Ouyen and SA border
(From Victorian Railays data)



Mileages from Melbourne are shown along horizontal scale. Heights shown in feet above sea level. Vertical scale is greatly exaggerated.

Ridge The ridge (Plate 21) is elongated in a N.N.W.-S.S.E. direction. It is generally between 20 and 100 feet high, and ½ to 1 mile across, with slopes between 1 and 3 per cent. The length varies from about ½ a mile to over 30 miles. A cross section across two adjacent ridges is shown in Figure 6. Ridges can vary in height along their length, and dunes are generally superimposed on them as shown in Figure 16. Surface materials vary in texture from sand to clay but the composition of the cores of the ridges has not been investigated.

There are occasional very large ridges named "physiographic highs" by Hills (1939). For example, the ridge at Walpeup (Figure 5) is 136 feet high and about 5 miles across. Because of their gentle slopes, and the presence of surrounding, smaller undulations, such large ridges are frequently not noticeable.

Ridges occupy most of the landscape in the Hopetoun and Tempy land systems in the southern part of the region. They occur also in the Central Mallee land system although at a much lower density. Ridges can be seen entering Big Desert and Berrook land systems but their presence or absence within the body of these areas is masked by dunes and jumbled dunes. Ridges with a similar orientation occur to the south of the region, extending as far as the Glenelg River (Blackburn and Gibbons 1956), and to the south-west in South Australia extending as far as the coast (Blackburn unpublished data).

Blackburn suggests that the ridges represent stranded coastal dunes deposited as the sea retreated south-westerly, because they form a continuous north-easterly extension to the aeolianite dunes adjacent to the present coastline. Hills (1939) suggests that the larger ridges, for example the Walpeup ridge, have been initiated by faulting. A third possibility is that some ridges are remnants of a peneplain dissected by water erosion, and the presence of lateritic remains on some ridges may be evidence of this. All three modes of origin may have been involved. Whatever the origin of the ridge cores, aeolian materials from a terrestrial source have been superimposed.

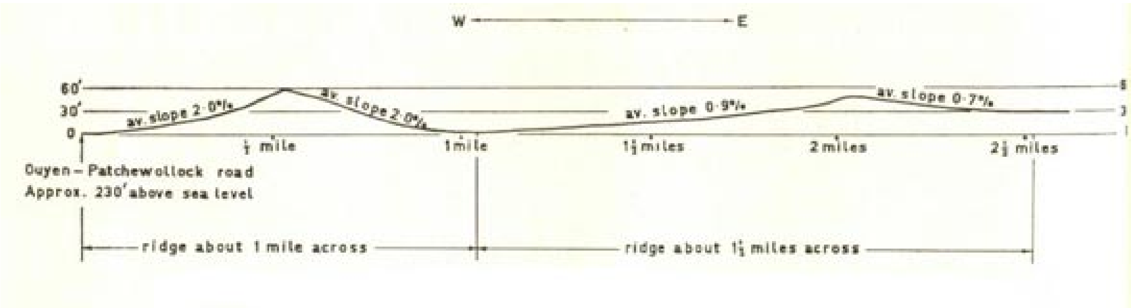


Fig 6 – An east-west cross section of two adjacent ridges along Patchewollock to Tempy Road (Tempy land system)

Hummock Among the complex aeolian undulations there is a fourth widespread land form, the hummock, which has not previously been recognized as a major land form in Australia. It is sub-circular in plan or only weakly elongated, in contrast to the strongly elongated dune, jumbled dune and ridge.

Hummocks occur as individual mounds on a plain but more usually the landscape they produce is complex, consisting of smaller mounds perched upon larger ones. The dimensions vary greatly from less than 100 yards to over 2 miles in diameter and from a few feet to over 100 feet in height. Slopes are gentle, usually between 1 and 3 per cent. Hummocks sometimes form a regular pattern as shown in Plates 22 and 28. They occupy some 70 per cent of the landscape in the Boigbeat land system and they are widespread in the Central Mallee, Millewa and Culgoa land systems.

The materials from which the smaller hummocks have been formed and the surface materials of the larger hummocks range in texture from sand to clay. As with other land forms within the region these deposits consist of a series of layers which are more or less parallel to the surface and which have been deposited during successive and periods. The nature and arrangement of the layers observed in a single transect across a simple hummock are described under parent materials in the soils section (Chapter IV). As for the ridges, the nature of the cores of the larger hummocks has not been investigated.

It is interesting to speculate on the aeolian processes which led to the build-up of the sub-circular land forms. They could be large-scale examples of "shrub coppice dunes" which form around clumps of low vegetation (Melton 1940). This process is in fact occurring within north-western Victoria where drift is entrapped by dillonbush (*Nitraria schoberi).* It is hard to imagine this kind of development occurring at the larger scale of the hummocks. On the other hand, the distribution of dunes compared with hummocks within the region supports the theory of the causative role of vegetation. For example, among the aeolian undulations in the relatively dry center and north, dunes predominate. They are replaced by hummocks in the moister south-east, in the Boigbeat and Culgoa land systems. Still further to the south-east, where the climate is even moister, the landscape does not contain significant areas of aeolian land forms. This three-stage progression may well reflect the gradation from deserts, through desert fringe areas to stable areas during a former arid period or periods. The suggestion is that, for dune-building, a sparse vegetative cover is required whereas a denser yet discontinuous cover favours hummock formation. Finally, under a continuous cover, aeolian undulations are not formed.

An alternative possible mechanism of build-up, at least of the larger hummocks, is the reorientation of dunes formed in a previous period of aridity. This may have occurred if the direction of the prevailing strong winds in the second arid period differed from that in the first.

Lunette This crescent-shaped ridge is well-known in southern Australia where it occurs on the eastern shores of lakes or dry lakes. The horns of the crescent point towards the west. In north-western Victoria lunettes are confined to the Raak, Tyrrell. Creek and Lindsay Island land systems (Plate 2) where they vary greatly in dimensions, depending largely on the size of the associated lake. The height varies from a few feet to about 100 feet, whilst the length ranges from less than a mile to about 14 miles. There is more than one lunette to the east of some lakes.

Lunettes are composed of layers which vary from sands to clays. Some layers are derived from the lake floors whilst others appear to have originated as regional dust deposits.

Copi Island Mounds formed on dry lakes in the Raak land system have been named "copi islands". They are composed mainly of layers of copi (powdered gypsum), gypsum and sandy materials. Limestone is sometimes present. A typical copi island has a surface layer of sand or loamy sand a few inches thick on the western faces and deeper towards the east. The second layer from the surface is white copi.

Copi islands are generally less than 15 feet high and less than a mile across (Plate 3), whilst they can be sub-circular, elongated or irregular in plan. The materials are derived substantially from the dry lake beds, with probable additions of regional dust. The sharp and frequently irregular boundaries indicate the sculpturing effect of wave action during periods in which the lake beds have been inundated.

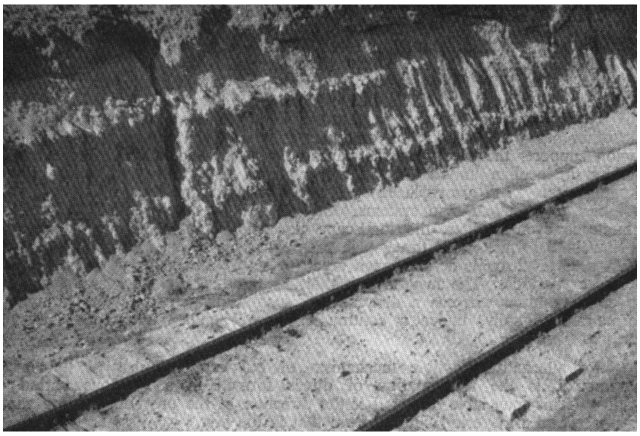


Plate 3 – Soil layers on a ridge between Murrayville and Danyo.
The two prominent bands are lime-rich. They are similar to those observed by Hills.