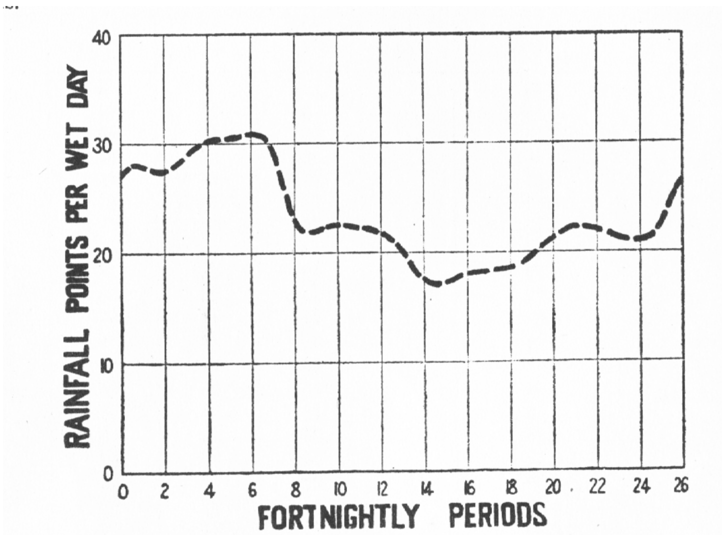
Period	Probability of Zero Rain	1/5	1/10	1/20	1/50	1/100
22	0.74	4	15	32	66	104
23	0.79		10	25	58	95
24	0.80		10	24	53	86
25	0.83		8	21	48	77
26	0.85		6	20	54	95

It is important when studying climate in relation to erosion to obtain some indication of intensity of rainfall at different times of the year so as to define the most dangerous periods. From the frequency distribution of the daily rainfall figures for each of the periods, an analysis (Table 1) has been made by E. A. Cornish* of the probability of the amounts of rainfall which can be expected to be equalled or exceeded on any one day in each period. For period 1 (Jan. 1-14), the figures 70 and 125 points given under the probabilities of 1/50 and 1/100 mean that these amounts of rain can be expected to be equalled or exceeded in the first period of the year, once in every 50 or 100 days of that period; or since there are only 14 days in the period in any one year these amounts can be expected to occur on 2 days in each 7 years or 1 day in each 7 years in that particular period.

An examination of Table 1 indicates certain periods in which there is a tendency for more intensive rainfall, namely, periods 1, 7, and 10 to 13. This variability of intensity throughout the year is further indicated by the curve in Fig. 5 of the average number of points of rain per wet day for the different periods of the year, showing that summer and autumn have the most intense rains.

Fig 5 - Points of rain per wet day during the year



All these measures of intensity so far used are based on 24-hour figures and consequently the difference between intensity of summer and winter rain will be even greater than already indicated, since summer rains are usually associated with thunderstorms of short duration and may fall during a period of an hour or two only of the 24, whereas the winter rains are usually of the type that continues for longer periods. Unfortunately this point cannot be supported by figures because there is no automatic recording rain gauge at Dookie College, and consequently intensities for periods of less than 24 hours are not known. However, figures available for Melbourne (Hughes 1939) when compared over a 24-hour period with Dookie, show that the probabilities are sufficiently alike to assume that they are a reasonable indication of the intensities which might be expected to occur at Dookie. A selection of probable intensities of rainfall in Melbourne is given in Table 2 and they indicate the high probability of intense rains.

* Officer-in-Charge, Section of Mathematical Statistics, CSIRO

For soil erosion investigations a more detailed study of intensities particularly for the time of the year considered most dangerous is necessary. This can only be done when there are several years of records from recording rain gauges. In the United States much has been done with such data, particularly by Yarnell (1635) and Blumenstock (1939).

Table 2 - Frequency of Rainfall of varying intensity at Melbourne in points per hour*

Duration	Once a Year	Once in 10 Years	One in 16 Years (calc)
5 min	197	432	610
10 min	159	324	472
20 min	112	231	324
30 min	88	188	257
1 hr	55	132	168
2 hr	38	76	107
4 hr	25	42	67
12 hr	12	24	32
24 hr	7	15	20

* Abstracted from Hughes (1939).

2. Temperature

Temperature records at Dookie College are only available for 36 years, but that is a sufficient length of time for the assessment of the average monthly maximum and minimum temperatures and their probable variations. The figures for Dookie College given in Table 3 are considered to be reasonably representative of the temperature conditions for the whole area. At Benalla the summer temperatures are slightly higher, and the winter slightly lower, when compared with Dookie College, while at Euroa the reverse conditions are found.

Table 3 - Temperature data Dookie College (Deg. F.)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Mean Max	86	86	80	71	63	55	53	60	64	70	78	84
Mean Min	58	59	55	49	44	41	39	40	44	47	51	54
Mean	72	72	68	60	54	48	46	50	54	59	65	69

Temperature is the least variable of the climatic features and the assessment of its reliability given in Table 4 shows the remarkable uniformity of most months. February appears to be the most variable month of the year, the next in order being April and November. The variability of April and November is not so surprising since in these months the seasonal weather is changing and a late or early spell of hot weather due to invasion of north winds from the warmer inland regions can easily cause the temperatures to depart from the mean. February, however, is a month which would be expected to show some degree of uniformity and the fact that it is the most variable is no less surprising than the uniformity of March occurring as it does between the variable months of February and April.

Table 4 - Reliability of Temperature (Dookie College)

(Percentage of years when means of maximum, minimum, and mean temperature for each month were witin 2^{o}F of the respective monthly means)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Mean Max	58	39	56	47	72	89	69	57	77	51	54	63
Mean Min	75	59	79	67	56	61	89	80	80	80	60	69
Mean	69	50	79	56	78	100	92	92	89	69	66	71

The maximum temperatures are more variable than the minimum throughout the year, but they show their greatest variability in the summer. Minimum temperatures show their greatest variability in the late autumn and early winter, but are remarkably uniform in late winter and early spring. The variability of the autumn and early winter is probably linked with the variable occurrence of the "break of season" rain. The months of June, July, and August are the coldest months of the year and the temperatures are sufficiently low to retard plant growth.

3. Influential Rainfall

As there are no evaporimeters in the area, evaporation figures have been computed from the saturation deficiency according to the formula *E* - 21.2 sd for a monthly value (Prescott 1938). The mena monthly rainfall, evaporation and *R/E* values for Dookie College are given in Table 5, which also indicates for each month the percentage of years when there has been influential rainfall, that is when the *R/E* value for the month has been greater than 0.3 (Trumble 1937).

Table 5 - Mean monthly figures of rainfall, evaporation, R/E and per cent years with R/E >0.3 for Dookie College (36 years' records)

	Rainfall (in)	**Evaporation (in)**	***R/E***	**Per cent Years *R/E* > 0.3**
January	1.30	9.03	0.14	14
February	1.21	8.35	0.14	17
March	1.48	6.13	0.24	28
April	1.76	5.66	0.31	47
May	2.01	1.76	1.13	89
June	2.61	0.80	3.26	100
July	2.05	0.85	2.42	97
August	2.28	1.10	2.08	92
September	1.91	2.16	0.88	89
October	2.03	6.15	0.33	67
November	1.34	6.61	0.20	25
December	1.21	7.76	0.16	11

Table 5 shows that influential rainfall occurs frequently in each of the months from May to September and is common also in April and October. It will be seen later that the common period of influential rain is six months and that in years when it begins in April it finishes in September, and when it starts in May it finishes in October. This is frequently so, but not always, for the period of influential rain does vary from the mean of six months and Fig. 6 shows the frequency distribution in terms of the percentage of years in which the influential rain period has been of different lengths. In 62 per cent of years the period of influential rain has been of either six or seven months' duration. The frequency distribution of amounts of influential rain given in Fig. 7 shows that in 68 per cent of years this is between 10 and 20 inches.

Fig 6 - Frequency distribution showing period of influential rain in months

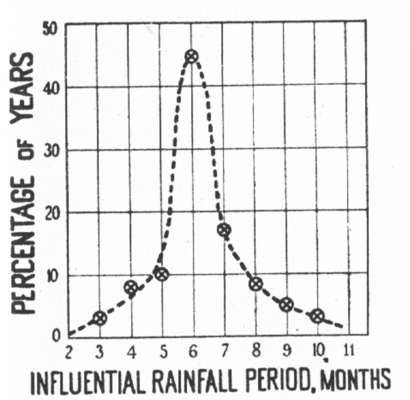
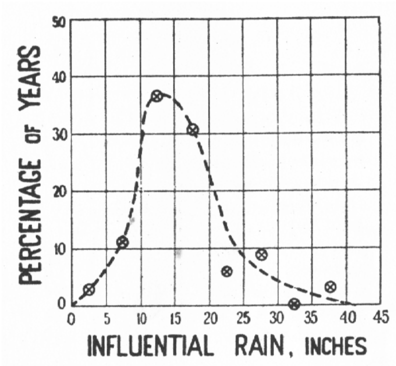


Fig 7 - Frequency distribution showing amount of influential rain in inches



The technique devised by Wark (1941) has been used to assess the occurrence of long periods of favourable rainfall conditions or of dry weather, for these are important aspects of climate in relation to agriculture and erosion. In Table 6 will be found the percentages of years in which each month in the three or five monthly periods quoted has had either influential rain or no influential rain.

From Table 6 it will be seen that from April to September there have never been on any occasion during the recorded period, three consecutive months with no influential rain, and from February to November there have never been five consecutive months of drought. Also, neither from November to February have there been three consecutive months, nor from October to May five consecutive months, of influential rainfall.

The moderately reliable nature of the climate is indicated by the fact that from May to September there have been at least three consecutive months of influential rain in almost 90 per cent of years and also from May to October there have been at least five consecutive months of rainfall in about 70 per cent of years.

The occurrence of the "break of season" rains in the autumn or early winter is an important variable in the agriculture of the district and farm management would be much easier if it could be forecast accurately. That, of course, cannot be done, but a study of past occurrences gives some useful information. The "break of season" rain is for this purpose considered to be in the first month of the year which has an *R/E* value greater than 0. 3 and is followed by at least two consecutive months with influential rain.

Table 6 - Percentage of years when specified periods have had three or five consecutive months of either influential rain or drought

Period	Five Months			Three Months	
	Rain	Drought		Rain	Drought
January-May		3	January-March		55
February-June	3		February-April	6	33
March-July	19		March-May	19	3
April-August	33		April-June	44	
May-September	78		May-July	89	
June-October	64		June-August	89	
July-November	22		July-September	83	
August-December	3	5	August-October	64	6
September-January	3	3	September-November	17	11
October-February		19	October-December	3	28
November-March		44	November-January		58
December-April		33	December-February		58

The percentage of years in which the "break of season" rain has occurred in each month is given in Table 7 and it will be seen that it has occurred in April or May in 72 per cent of years and in June in only 8 per cent of years. Some idea of the finish of the season can be gained from Table 7, which also shows the percentage of years for which each month has been the end of the influential rain period.

Table 7 - Occurrence of beginning and end of influential rain season

(Percentage of years when break of season and end of season have occurred in months shown)

Break of Season		End of Season	
February	5	July	5
March	15	August	5
April	25	September	22
May	47	October	46
June	8	November	19
		December	3

Although these tables help in assessing the beginning and ending of the growing season, there are some points of agricultural importance for which they give no help. For example, if there is influential rain in March it may represent the 1 "break of season" in which case the following months will be wet, but on the other hand April and May could be dry and the real break come in June. Such problems are partly answered by the figures given in Table 8, which show the percentages of occasions when an influential rain in a month did actually constitute the break of season.

Table 8 - Percentage of years when influential rain in specified months was actually a break of season rain

	Feb	Mar	Apr	May	June
Percentage of years	33	71	90	100	100

An influential rain in February will be a "break of season" rain on only 33 per cent of occasions, but in May and June following a dry month it has ,represented the break of season rain on every occasion. The amount of rain which can be considered influential for each of these months will vary because the evaporation is diminishing from February to June, and the amounts that can be considered, on an average, influential for each of the months are given below:

February	March	April	May	June
pts	**pts**	**pts**	**pts**	**pts**
250	200	190	60	30

From the above analysis of the climatic records it is possible to make a general assessment of the climate in relation to agriculture and also to its effect in causing soil erosion. In relation to agriculture it has been shown that there is usually a period of six months' influential rainfall beginning most frequently in May and ending in October, the amount of influential rain being between 10 and 20 inches. This constitutes the growing season, of which the months of June and July are usually too cold for much plant growth so that the success of a season depends largely on the spring rain of late August, September, and October. In the rare years when the season finishes early, crop yields are low and pasture growth is poor. This is well demonstrated by the wheat yields at Dookie College for 1938 and 1944.[*] In 1938 there was only a three months' season, the months being June, July, and August, whereas in 1944 there was a four months' growing season from April to July. Both years had about the same total amount of influential rainfall, namely 6.70 and 6.90 inches, and yet in 1938 the yield was 23 bushels per acre, but in 1944 only 11 bushels per acre. This difference is mainly due to the rain in August in 1938 which enabled the crop to reach maturity. The fact that years such as 1944 do occur on occasions makes pasture management difficult, for it is in such years that farmers find themselves overstocked and the country left bare in the following summer. Such conditions, in conjunction with the higher intensity rains of the summer and autumn, which incidentally appear to occur more frequently after such a dry season, are the main cause of erosion in the area.

III. VEGETATION

So much of the area has now been cleared that it is impossible to reconstruct fully the original distribution of the vegetation except in the most general terms. From the areas of uncleared country and the roadside vegetation it is possible to form some idea of the kinds of cover in different parts of the area and in fact several communities can be defined. Most of the area was covered by dry sclerophyll forest, but in the north and north-western parts of the area and also in the south on the plains, there was savannah woodland, while in the mountains in the south-east there still remains wet sclerophyll forest. The grasses associated with the savannah woodlands were *Danthonia spp.* and *Stipa spp.;* the latter species are said to have constituted about 10 per cent of the grass population. When the dry sclerophyll forest was cleared the areas were invaded by these pastures. Subsequent degradation of the pastures and consequent erosion, particularly on the central hills, has led to changes of vegetation. It would be an interesting ecological study to trace the plant succession on these areas following different degrees of degradation and erosion down to the stage where the only remaining vegetation is the lichens which cover the bare ground and stones.

There are eleven vegetation communities which are thought to have existed formerly and these are described below.

1. Yellow Box *(Eucalyptus melliodora)* - Pine *(Callitris robusta)*
This savannah woodland type of community is found on well-drained soils in the drier parts of the area (18-20 in. rainfall). It occurs on the red soils (Dookie-Currawa Association) in the vicinity of Dookie and also the light ridge soils (Shepparton-Broken Association) associated with the red-brown earth plains in the north and north-western parts of the area. In some places almost pure stands of pine are found on the Dookie clay loam.

2. Yellow Box (E. *melliodora)* - Grey Box (E. *hemiphloia)*

[*] Figures supplied by Mr H Park, Farm Manager

This savannah woodland type of community is also found on the drier parts of the area on the lighter red-brown earth soils and the light ridges associated with them in the north and north-western parts of the area. It appears to replace the previous community on similar situations in a slightly higher rainfall.

3. Yellow Box (E. *melliodora) - Forest* Red Gum *(E. tereticornis)*

The community is found in moist but well-drained situations, particularly along the Broken Creek in the north-eastern part of the area on soils of the Shepparton-Broken Association and also along the creek lines in the southern part of the area on soils of the Earlston-Koonda Association.

4. River Red Gum *(E. camaldulensis)*

This community is found in all parts of the area which are moist and poorly drained and suffer from periodic inundation. It usually occurs in pure stands and is characteristically a "swamp" community.

5. Grey Box (E. *hemiphloia)*

Almost pure stands of grey box are found on the area either as a dry sclerophyll forest or as savannah woodland. It occurs as a dry sclerophyll forest on the hills in the middle of the area, the soils being those of the Gowangardie-Caniambo Association; and as savannah woodland on the soils of the Lemnos-Goulburn Association in the north and north-western parts of the area.

6. Grey Box (E. *hemiphloia)* - River Red Gum *(E. camaldulensis*)

Grey box and red gum form a savannah woodland type of community on the wet, poorly drained areas in the southern part of the area. It occurs almost entirely on the heavy crabholey soil, the Upotipotpon clay.

7. Grey Box *(E. hemiphloia*)-Red Box *(E. polyanthemos)*

This is a savannah woodland community occurring only as a narrow strip between the 22 in. - 24 in. isohyets along the foot of the south-eastern hills. White box (*E. albens)* is an irregularly occurring minor species in this community.

8. Red Box *(E. polyanthemos)* - Red Stringy Bark *(E. macrorrhyncha)*

Red box and red stringy bark are a dry sclerophyll forest type of community occurring along the lower slopes of the south-eastern hills where the rainfall is in the region of 25 inches or more per annum. As the rainfall and elevation increase, its place is taken by the wet sclerophyll forest on the top of the hills.

9. Peppermint *(E. radiata)* - Stringybark *(E. capitellata)* - Blue Gum *(E. globulus)*

This wet sclerophyll forest community occurs on the top of the south-eastern hills where the rainfall is about 28 - 30 inches per annum.

10. Green Mallee *(E. virldis)*

Pure stands of green mallee are found on the tops of some of the hills in the parishes of Gowangardie and Upotipotpon. Such occurrences of mallee are not uncommon in some parts of northern Victoria, eastward from the true mallee area, but this seems to be the most easterly occurrence.

11. Sheoak *(Casuarina stricta)*

Small patches of sheoak are to be found occurring within other communities. It seems to be confined to the more stony areas both on the central and south-eastern hills. There have been some occurrences in the grey box savannah woodland, but most of it has now been removed.

IV. GEOLOGY AND PHYSIOGRAPHY

Although the district presents some interesting geological and physiographical features, practically no former investigations have been made and consequently it is impossible to give an authoritative account of the geological history of the area.