2 CLIMATE

The catchment has a Mediterranean climate - mostly sub-humid. The highest areas in the south are humid and conditions on the northernmost plains tend towards semi-arid.

The area contains 15 rainfall-recording stations, and temperature records are available for Charlton, St Arnaud, Avoca and Maryborough. These and other data from the Commonwealth Bureau of Meteorology form the basis of the following discussion.

Rainfall

Most precipitation occurs as rain, with only an occasional snowfall being recorded at Mount Lonarch and Mount Avoca. However, mountains such as the Pyrenee Range may have significant fog-drip from trees enveloped by low clouds (Costin and Wimbush 1961).

A pronounced rain shadow from the Pyrenee Range influences about half of the area, from St Arnaud (499 mm) southwards to Amphitheatre (609 mm), as shown in Figure 2. Mount Avoca has the highest annual rainfall (approximately 650 mm) and yet Avoca, 10 km to the east, has only 540 mm.

Monthly rainfall records are given in Table 1, while Figure 3 shows values for selected stations in graph form. A distinct seasonal rainfall pattern prevails throughout the catchment: summer has the lowest rainfall, averaging 20 to 35 nim per month; and winter is the wettest season, averaging45 to 70 mm per month.

Table 2 shows the probability of receiving sufficient rainfall to support plant growth in each month. The rainfall is more reliable during the cooler months and in the higher-rainfall areas.

The intensity of individual storms is an important factor affecting erosion and run-off. From rainfall data at Charlton, J. W. Cooke (personal communication) has recorded the months in which the heaviest storms occurred, as shown in Figure 4. In 40 of the 100 heavy storms recorded, rainfall reached or exceeded 53 ram within 2 days. The highest probability of intense storms occurs during the summer months, coinciding with the period when soils on agricultural land tend to be bare.

Table 1 - Average monthly and annual rainfall (mm)

Station	No. of years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Amphitheatre	78	32	35	37	44	57	64	66	70	64	57	45	42	609
Avoca	89	26	38	30	40	50	61	59	60	52	48	38	36	537
Bealiba	82	25	31	30	32	48	48	49	50	45	44	33	29	461
Burkes Flat	30	22	31	24	29	44	50	50	45	47	38	25	28	435
Charlton	91	23	27	28	32	42	49	43	45	41	39	29	27	422
Coonooer Bridge	30	20	29	22	27	37	41	46	39	42	36	25	27	394
*Dunolly	30	28	39	28	34	44	56	56	53	55	42	32	34	501
*Maryborough	30	25	38	28	34	45	56	57	54	55	41	36	41	510
Moonambel	37	26	35	28	39	61	72	74	70	64	51	32	39	590
Natte Yallock	41	22	27	28	31	41	52	48,	47	47	38	31	33	447
Redbank	76	24	37	31	39	58	68	69	68	59	52	37	32	573
St Arnaud	93	25	30	28	38	53	59	55	56	48	47	34	29	499
Stuart Mill	43	24	26	33	44	65	83	65	71	56	55	44	36	603
*Wedderburn	91	25	29	29	33	49	54	49	50	47	43	33	30	470
Wychitella	30	18	27	27	27	42	45	44	42	46	34	25	27	404

*Adjacent to catchment

Source: Bureau of Meteorology

Figure 2 - Isohyet map showing average annual rainfall

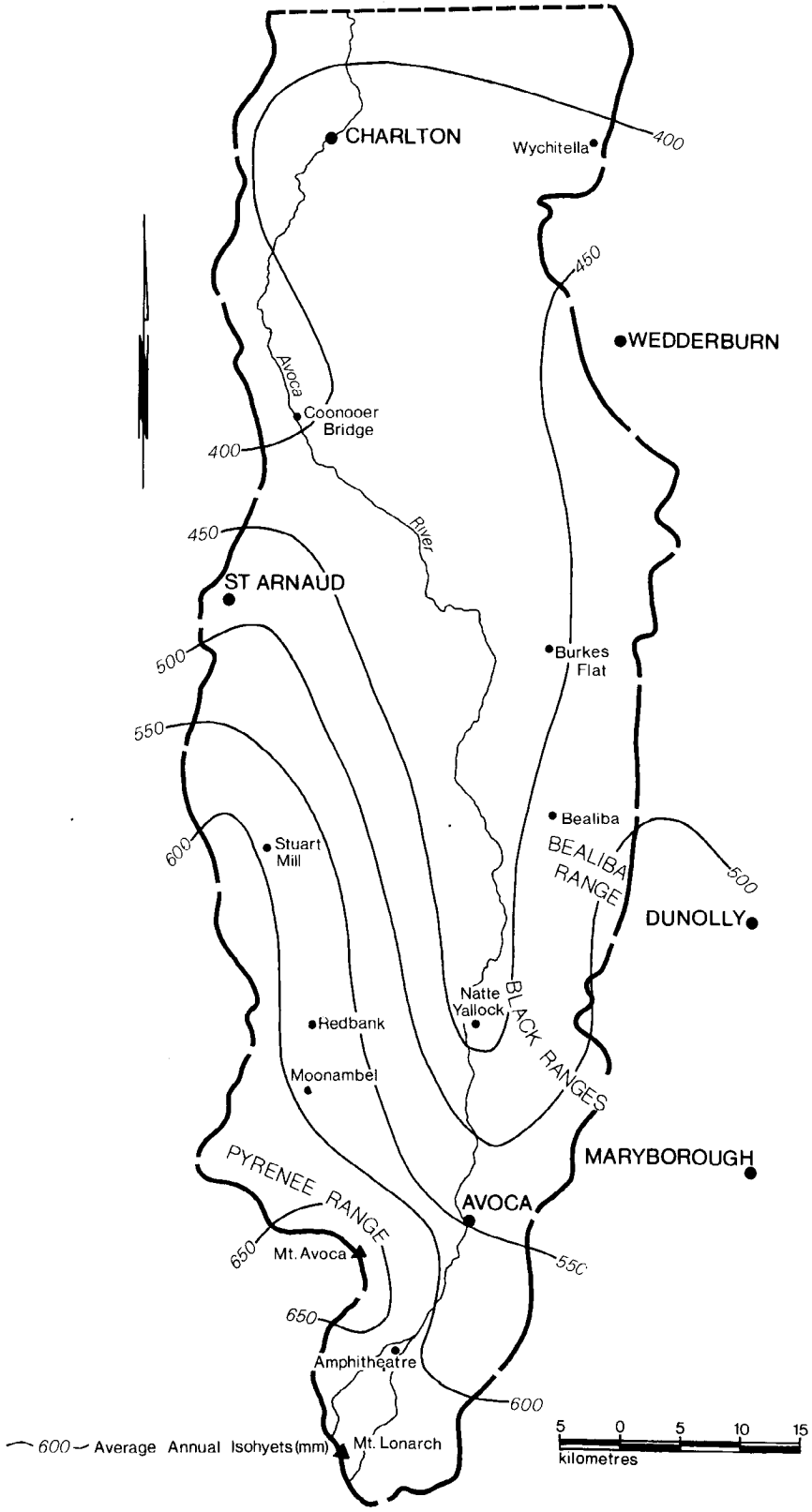


Table 2 - Percentage frequency of occurrence of rainfall equal to or greater than the 'effective' amount

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Charlton	9	12	25	37	69	89	86	87	67	36	16	12
*Wedderburn	10	17	24	44	73	92	88	90	74	45	22	16
St Arnaud	12	13	25	48	77	93	94	91	79	50	22	14
Stuart Mill	10	16	32	61	86	96	97	95	85	71	32	25
*Maryborough	is	22	31	61	77	96	93	93	82	55	34	25
Avoca	13	23	28	57	86	100	97	95	90	60	31	28

*Adjacent to catchment

Source: Bureau of Meteorology

Figure 3 - Average monthly rainfall at selected stations '

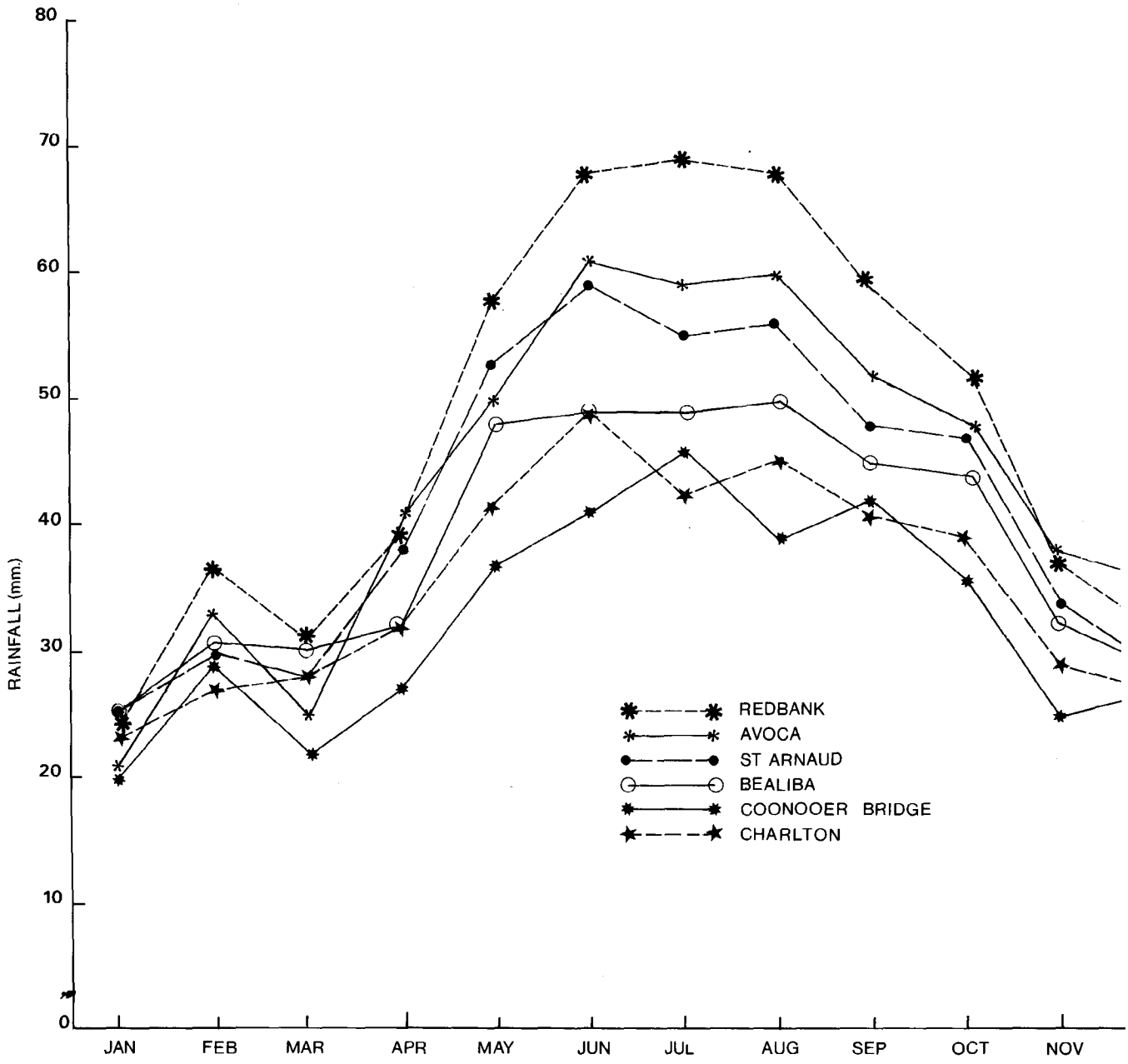
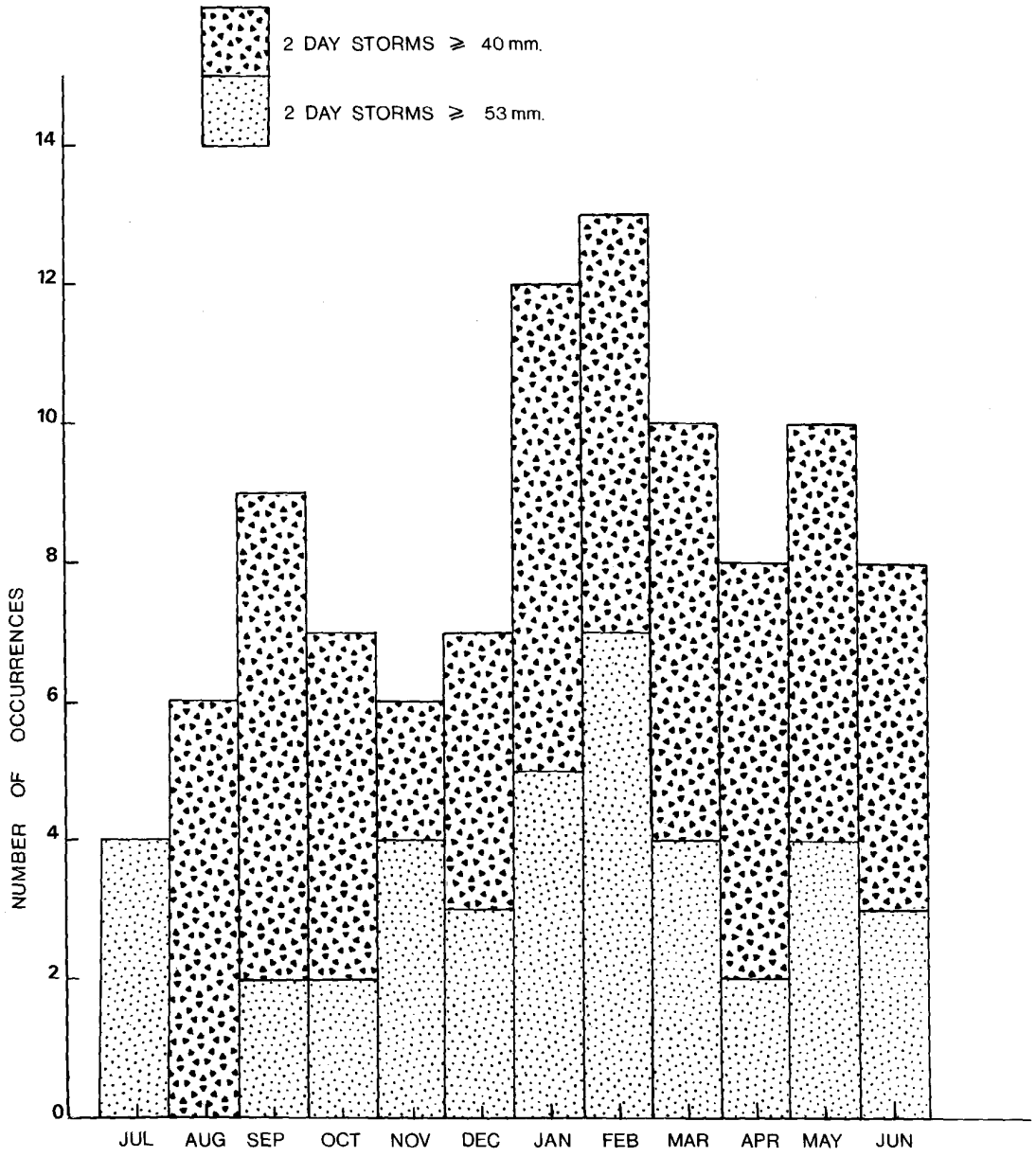


Figure 4 - Distribution of 2-day storms at Charlton



Temperature

Table 3 provides temperature data for Charlton, St Arnaud, Avoca and Maryborough, all of which, except for Charlton, are at approximately the same elevation. Monthly maximum, minimum, and mean temperatures differ only slightly between stations throughout the lowlands of the catchment. The Pyrenees Range - some 400 to 500 m above the plains - is cooler, but has no recording stations. The approximation can be made that temperatures decrease in inland Victoria by 0.6° C for every 100 m rise in elevation. On this basis the upper slopes of the ranges are 2-3° C cooler than the lowlands.

As shown in Table 4, frosts occur more often in the southern half of the catchment, which is influenced by the cold air flow into the valley from the Pyrenees Range. Charlton, being on the open plains and lacking the insulating effect of cloud on cold winter nights, has a higher incidence of frosts than St Arnaud.

Table 3 - Average monthly maximum, minimum and mean temperatures

Station and elevation	Average temperatures	No. of years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Charlton	Maximum	41	30.2	30.4	26.7	21.9	17.4	13.8	13.3	15.0	17.9	21.4	26.0	29.0	21.5
120 m	Minimum	41	13.8	14.3	11.7	8.4	6.0	4.2	3.4	4.0	5.6	7.4	10.2	12.6	8.5
	Mean	41	22.0	22.4	19.2	15.2	11.7	9.0	8.4	9.6	11.7	14.4	18.0	20.7	15.2
St Arnaud	Maximum	40	28.8	28.8	25.5	20.4	16.0	12.8	12.3	14.2	16.7	20.2	24.2	27.5	20.6
240 m	Minimum	40	13.4	13.9	11.7	8.7	6.3	4.2	3.7	4.4	5.8	7.6	9.8	12.1	8.5
	Mean	40	21.1	21.4	18.6	14.6	11.2	8.5	8.0	9.3	11.3	13.9	17.0	19.8	14.6
*Maryborough	Maximum	38	28.7	28.9	25.5	20.3	16.2	12.6	12.2	13.8	16.8	20.6	24.3	26.9	20.6
240 m	Minimum	38	12.7	13.0	11.0	8.1	6.0	4.3	3.4	4.0	5.3	7.1	9.4	11.4	8.0
	Mean	38	20.7	21.0	18.3	14.2	11.1	8.5	7.8	8.9	11.1	13.9	16.9	19.2	14.3
Avoca	Maximum	41	28.0	28.2	24.7	19.7	15.7	12.2	11.7	12.7	16.2	19.7	23.6	26.2	20.0
240 m	Minimum	41	12.4	12.6	10.4	7.7	5.4	4.0	3.2	3.6	5.0	6.8	9.1	11.0	7.6
	Mean	41	20.2	20.4	17.6	13.7	10.6	8.1	7.5	8.2	10.6	13.3	16.4	18.6	13.8

*Adjacent to catchment

Source: Bureau of Meteorology

Evaporation

There are no published records of evaporation from a free water surface based on readings within the catchment. Estimates by the Bureau of Meteorology indicate that the annual evaporation ranges from about 1150 mm in the southern part of the catchment to 1250 mm in the north. Monthly values range from 25 to 35 mm in July up to 200 mm or more in January.

Potential evapotranspiration equals approximately eight-tenths of evaporation from an Australian standard tank evaporimeter. Values have been calculated for three stations, asshowninTable5, by the method of Thornthwaite (1948) as modified by Leeper (1950).

Wind

In the north, as shown in Table 6, wind speed is generally less than 20 km per hr, but between September and January a significant proportion of days have winds between 20 and 50 km per hr. Wind direction tends to be from the south during the spring and summer, but more westerly during autumn and winter.

In the south, as shown in Table 7, the days are usually calm or have a southerly wind of less than 20 km per hr.

Table 4 - Monthly frequencies of frost occurrence

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Charlton													
Severe frost < O^0C	-	-	-	-	0.3	3.1	4.2	2.2	1.0	-	-	-	10.8
Light frost 0-2.2^{0}C	-	-	0.5	0.9	2.7	4.3	4.9	4.9	4.2	1.7	-	0.2	24.3
St Arnaud													
Severe frost < O^0C	-	-	-	-	0.3	2.3	3.2	1.6	0.3	0.1	-	-	7.8
Light frost 0-2.2^{0}C	-	-	-	0.2	2.6	3.5	4.5	3.5	3.0	0.6	-	-	17.9
***Maryborough**													
Severe frost < O^0C	-	-	-	0.1	0.2	2.6	3.3	1.1	0.8	0.1	-	-	8.2
Light frost 0-2-2^{0}C	-	0.1	0.1	0.8	2.6	5.7	7.0	4.7	4.1	0.7	0.2	-	26.0
Avoca													
Severe frost < O^0C	-	-	-	-	1.6	4.0	5.0	2.3	1.7	0.1	-	-	14.7
Light frost 0-2-2^{0}C	-	-	0.2	0.6	4.7	4.3	4.9	3.8	4.1	2.0	-	-	24.6

*Adjacent to catchment

Source: Foley (1945)

Table 5 - Calculated potential evapotranspiration (mm)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Avoca	117	99	76	so	36	20	19	26	44	57	72	97	705
St Arnaud	121	104	83	55	32	20	19	26	36	61	76	99	732
Charlton	127	112	88	57	34	32	20	27	36	63	80	107	772

Table 6 - Average monthly wind direction, percentage frequency and speed for Charlton at 0900 hrs

Wind direction	Percentage frequency											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
N	8	7	11	10	5	6	6	10	10	7	8	5
NE	is	23	15	14	11	14	6	9	8	17	12	13
E	9	5	3	3	3	-	2	3	4	2	4	5
SE	21	27	21	9	5	4	3	4	11	14	14	17
S	is	13	10	10	8	5	4	5	13	13	16	15
SW	8	5	11	8	11	6	6	11	13	12	16	16
W	5	3	3	14	16	9	19	17	16	8	13	6
NW	5	6	5	6	8	9	12	10	6	8	4	6
Calm	12	11	20	25	34	46	43	30	20	19	13	17
Wind speed (km per hr)												
0-5	25	28	15	19	24	30	21	28	15	29	12	22
6-10	33	24	19	26	24	18	22	17	21	23	28	30
11---20	21	25	26	21	17	7	10	14	24	15	27	18
21-30	7	10	17	7	2	-	3	10	14	10	12	10
31-40	1	2	1	2	-	-	1	1	5	4	8	3
41-50	1	-	-	-	-	-	-	-	1	-	1	-

Source: Bureau of Meteorology

Climatic control of plant growth and water supply

The combined effects of temperature and moisture availability on seasonal plant growth are illustrated in Figures 5, 6 and 7.

Low temperatures restrict or prevent plant growth. It is accepted that in a month with an average temperature of 10^0C or less plant growth is greatly retarded (Trumble 1939) and when the temperature is 5.5^0C or less plant growth is negligible (Manley 1945). There is little difference between the lowland stations Charlton, St Arnaud and Avoca in the period during which growth is inhibited. Avoca in the south may have 3-4 weeks longer than Charlton in the north. The period of retarded growth (5.5 to 10^0C) extends from June to August at lowland stations throughout the catchment.

The interaction between rainfall and potential evapotranspiration is expressed by the curve for soil moisture. This must be taken as a guide only, because of various factors such as approximation of the potential evapotranspiration calculation and incomplete infiltration of rain into the widespread soils with poorly structured surfaces and slowly permeable subsoils. Another approximation is the 100 mm available water storage, a value commonly used for agricultural crops and pastures.

At Avoca (see Figure 5) plant growth usually begins in late April, when rainfall exceeds potential evapotranspiration, and continues until declining temperatures slow its rate. Available moisture in the soil builds up to 100 mm, and then excess moisture augments stream flow via run-off or deep percolation. Growth rate responds to the rising temperatures of spring. After evapotranspiration exceeds rainfall, plants rely on stored moisture, which is exhausted in November.

On this basis, Avoca has a growing season of approximately 7 months and contributes some 50 mm yearly to water supplies.

At St Arnaud (Figure 6) the break in season occurs, on average, in early May, but similarly, declining temperatures inhibit growth in winter. The growth rate increases in August, continuing vigorously until soil moisture is exhausted. St Arnaud has a growing season of approximately 6 months and contributes some 40 mm yearly to water supplies.

Figure 5 - Average plant growth patterns at Avoca as influenced by rainfall, potential evapotranspiration, temperature and soil moisture in storage

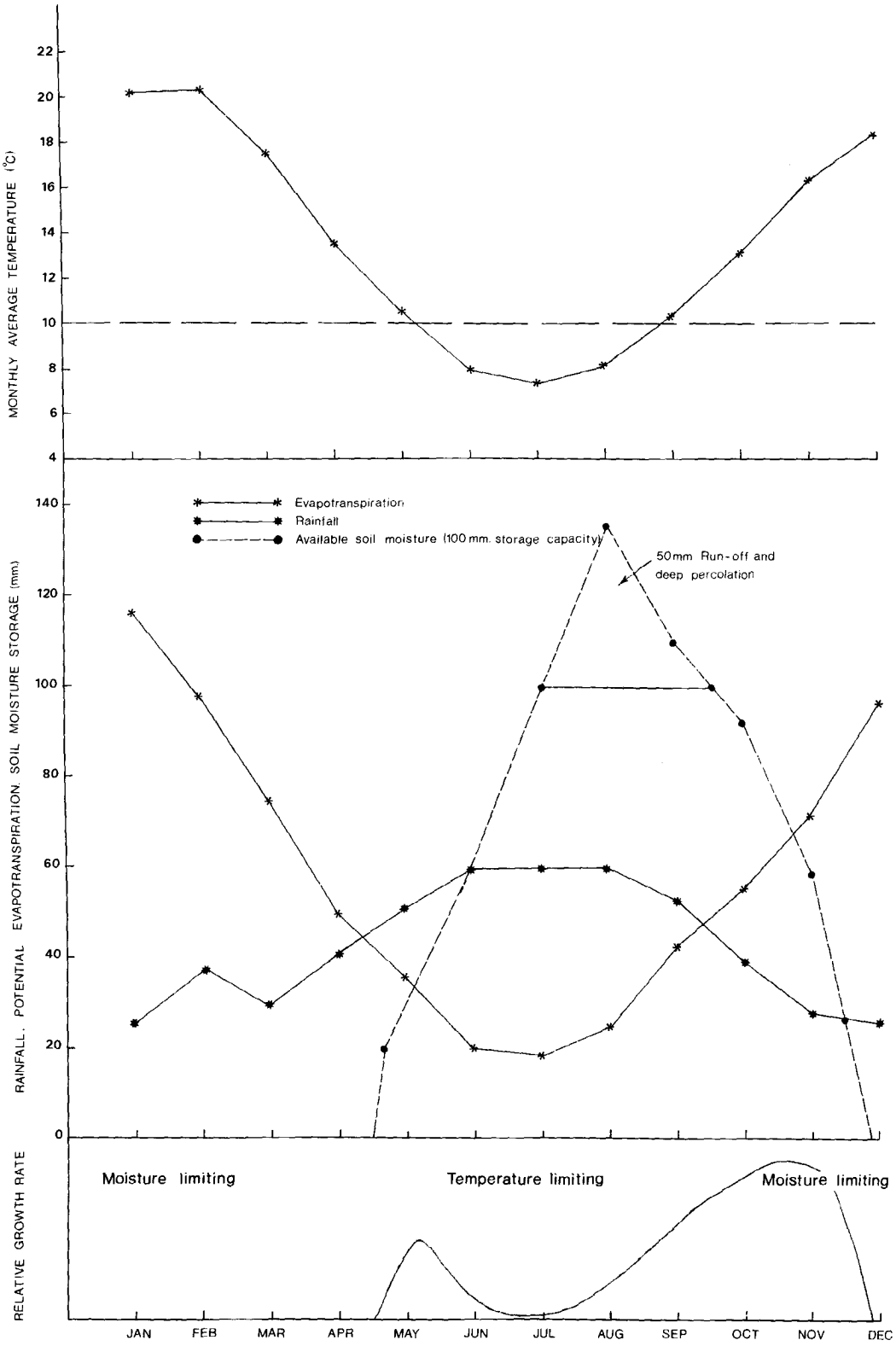


Figure 6 - Average plant growth patterns at St Arnaud as influenced by rainfall, potential evapotranspiration, temperature and soil moisture in storage

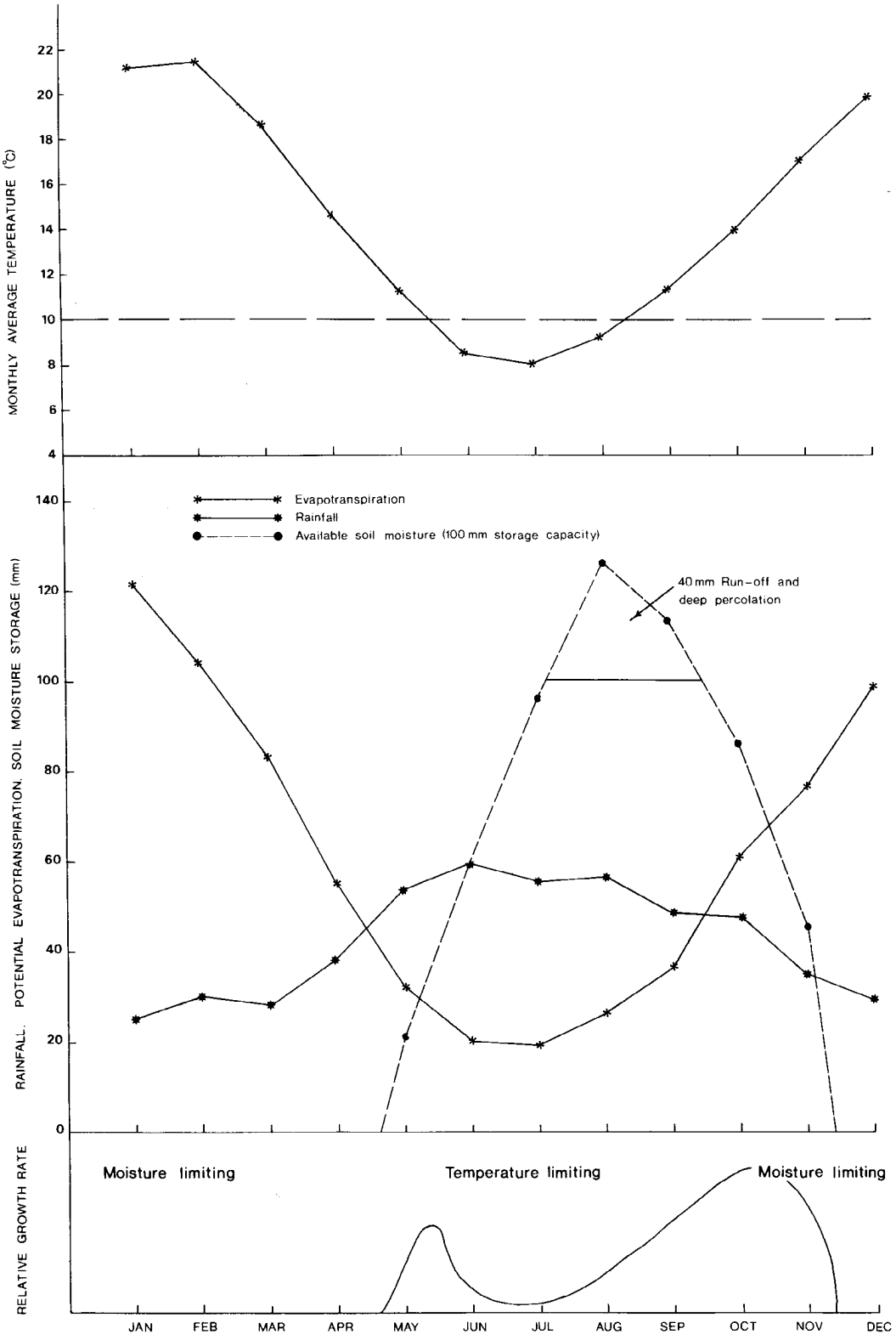


Figure 7 - Average plant growth patterns at Charlton as influenced by rainfall, potential evapotranspiration, temperature and soil moisture in storage

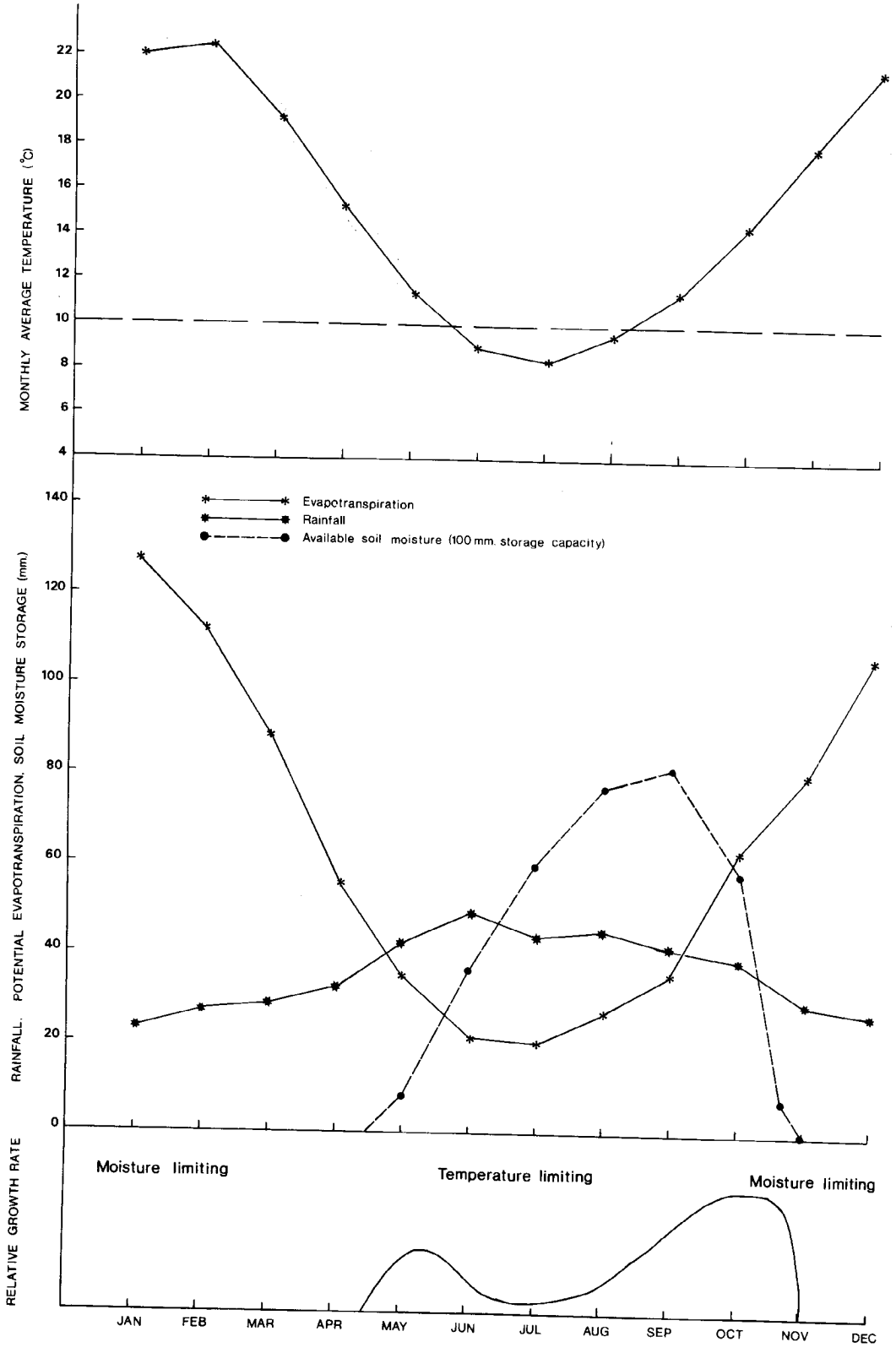


Table 7 - Average monthly wind direction, percentage frequency and speed for Avoca at 0900 hrs

Wind direction	Percentage frequency											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**No**	**Dec**
N	9	10	5	8	7	6	9	6	5	9	10	12
NE	2	-	1	-	-	1	1	-	-	1	1	1
E	-	-	1	-	-	-	-	-	-	1	-	-
SE	1	7	1	2	-	1	1	-	1	2	3	6
S	36	42	43	17	13	7	7	1	17	32	37	31
SW	2	3	5	3	1	2	2	2	6	3	5	5
W	2	1	-	1	1	-	-	-	3	1	3	1
NW	2		2	3	1	1	4	4	4	2	5	2
Calm	47	38	53	67	75	82	75	74	63	48	36	43
Wind speed (km per hr)												
0-6	3	4	2	2	2	1	-	1	6	3	6	6
6---10	30	33	23	19	19	12	18	18	17	21	34	28
11-20	13	14	17	9	3	3	5	4	11	20	15	16
21---30	48	8	3	2	-	2	-	2	2	7	6	5
31-40	2	2	1	1	-	1	1	1	-	1	3	2

Source: Bureau of Meteorology

At Charlton (Figure 7) the break in season, slow winter growth and spring flush occur at similar times to those at St Arnaud. However, the rainfall is insufficient for the soil to store 100 min of moisture, resulting in no contribution to stream flow and a short 5-month growing season.

The growing seasons of 5, 6 and 7 months for Charlton, St Arnaud and Avoca respectively correspond to those calculated by the formula for effective rainfall. Table 2 indicates the growing season, as shown by the number of months with a 50% or higher chance of having effective rainfall.