2. CLIMATE

The data presented in this section have been obtained largely from `Resource Survey of the Upper Murray Region' (Central Planning Authority 1949), `Frost in the Australian Region' (Foley 1945) and `Climatic Averages, Australia' (Commonwealth Bureau of Meteorology 1956).

The study area is located within about 30' of 37°S latitude, and therefore comes under the influence of easterly-moving, dry, warm, anticyclonic systems in summer and moist, cool, north-easterly-moving, cyclonic systems in winter. The regional climate is regarded as Mediterranean or temperate rainy with dry, warm summer (Csb) in terms of the Koppen classification (Strahler 1960).

Rainfall

Because of the mountainous nature of much of the area, considerable variation in local climates occurs, especially in average annual rainfalls (see Figure 2). These range from about 750 mm in the northern valleys (such as at Moyhu) to almost 2000 mm (for example, at Mount Buffalo) on some high country. Table 1 lists average monthly and annual rainfall data for a number of stations in the area, showing the trend for the annual average to increase from north to south as the elevations of the land masses increase. This general trend is also apparent in all months.

Snow falls on the higher country in winter; most of the area above about 1400 m is snow-covered for at least 4 to 6 weeks in most years, and areas down to about 1000 m have intermittent snow cover during that period.

The percentage frequency of occurrence of rainfall equal to or greater than the `effective' amount is presented in Table 2. This may be used as a measure of the reliability of rainfall for the maintenance of plant growth. `Effective' rainfall is defined (Central Planning Authority 1949) as the amount of rain needed to start germination and maintain growth above wilting point, and is based on calculation of the balance between rainfall and evaporation.

Temperature

Temperature data for the area are not very comprehensive (Table 3). Hotham Heights and Mount Buffalo are both high-elevation stations (1860 m and 1335 m respectively); Myrtleford is assumed to be representative of the northern valleys (about 150 m elevation); and Beechworth, although north of the study area, has been regarded as representative of country at intermediate elevation (about 550 m).

Snow is the dominant form of winter precipitation in the high mountains. Snow poles mark the outer edge of the road over Mount Hotham.

Throughout the study area the hottest months are January and February, and in the north (Myrtleford and Beechworth) the mean temperatures then are almost high enough to push those areas into the ‘dry, hot’ classification of Koppen, for which the criterion is mean temperatures higher than 22°C.

July is the coldest month at all stations, and at Hotham Heights the mean monthly temperatures for June, July and August are all below 0°C. In this regard Hotham Heights does not quite qualify as a ‘snow climate’ according to Koppen, whose criterion is a coldest-month mean temperature under -3°C.

Temperature trends are the inverse of the general rainfall trend, decreasing with increasing elevation. However, minimum-temperature inversions occur; these are particularly pronounced at high elevations, where severe radiation cooling at night may occur. Such inversions result from the sinking of cold, denser air into low parts of the landscape.

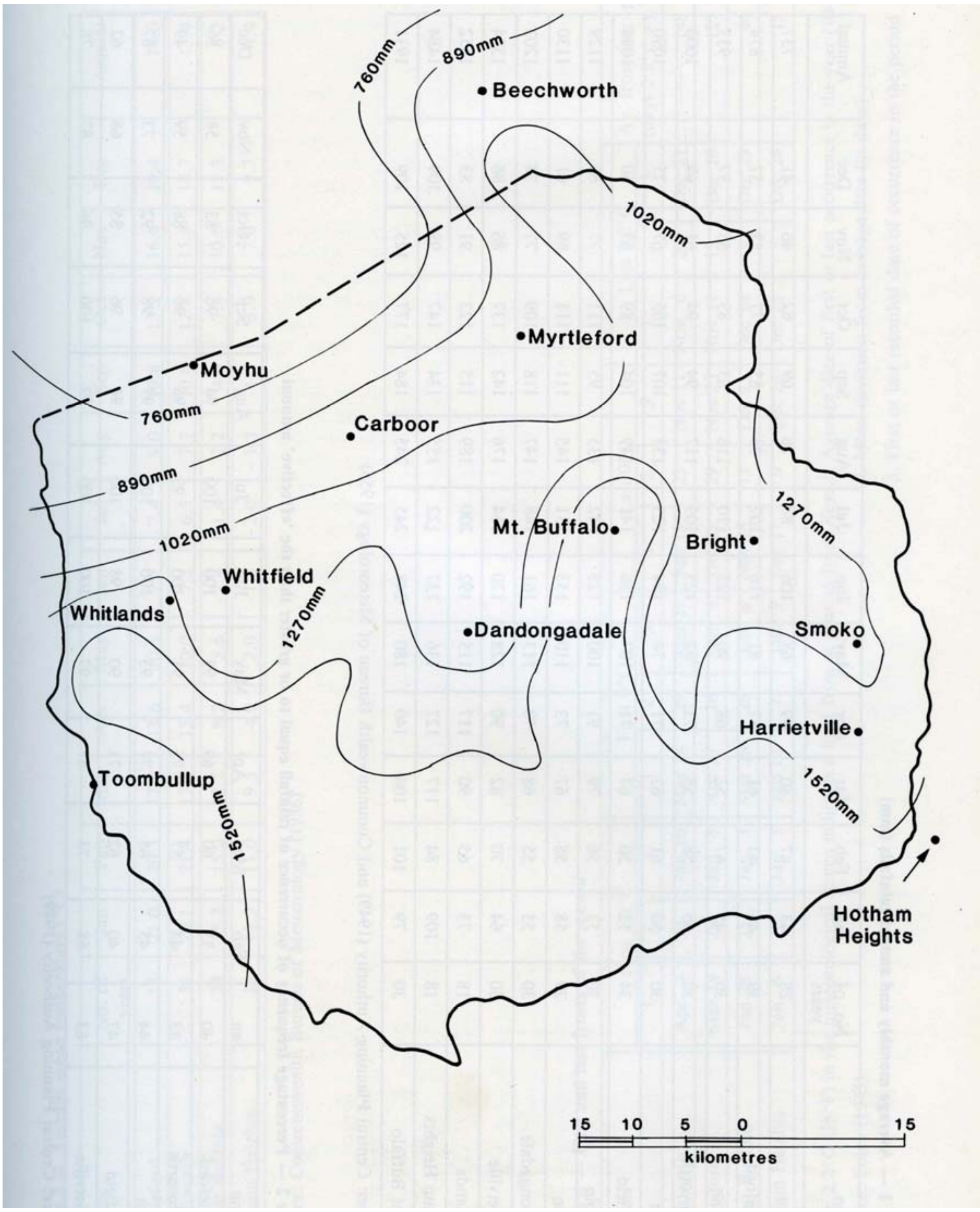

Figure 2 – Average annual rainfall

Table 1 – Average monthly and annual rainfalls (mm)

Station	No. of years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Moyhu	28	43	47	40	49	68	106	88	78	69	62	46	41	737
Myrtleford	39	46	43	61	57	81	116	102	98	83	77	52	57	874
Carboor	30	45	47	52	68	90	125	110	116	85	83	55	57	933
Beechworth	30	46	58	58	73	92	125	109	117	94	94	61	69	1000
Bright	30	50	61	63	71	74	134	123	133	107	105	67	75	1090
Whitfield	34	53	50	67	71	107	156	141	139	104	89	63	60	1098
Eurobin	30	53	56	79	91	100	125	142	135	95	111	77	65	1129
Smoko	29	58	58	67	73	110	133	131	145	111	111	69	61	1130
Dandongadale	30	55	55	68	78	113	161	148	147	118	109	77	74	1203
Harrietville	30	64	70	82	90	128	170	164	176	142	137	86	86	1394
Whitlands	18	73	65	90	117	115	192	200	189	115	123	91	83	1452
Hotham Heights	18	109	84	117	127	136	137	122	155	134	147	98	109	1484
Mount Buffalo	30	79	101	106	140	180	248	245	245	184	177	125	109	1933

Sources: Central Planning Authority (1949) and Commonwealth Bureau of Meteorology (1956)

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
Myrtleford	40	33	60	69	93	100	100	94	96	83	58	56
Beechworth	33	44	57	75	91	100	99	96	96	88	59	49
Bright	44	45	68	77	93	100	100	97	98	92	73	67
Whitfield	47	40	62	71	90	98	100	96	96	85	68	62
Harrietville	63	68	73	87	97	100	100	99	100	96	87	78

Source: Central Planning Authority (1949)

Table 3 – Average mean temperature (^oC)

Station	No. of years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Myrtleford	15	21.0	20.3	17.7	13.6	10.5	7.7	7.4	9.0	10.8	13.2	16.6	19.4	14.0
Beechworth	32	20.1	21.4	17.8	13.4	10.0	7.2	6.5	7.7	10.0	12.8	15.8	18.7	13.4
Mount Buffalo	28	15.2	15.0	12.7	8.2	5.6	2.4	1.4	2.2	4.6	7.4	10.6	13.3	8.2
Hotham Heights	18	11.3	11.0	9.5	4.9	2.0	-1.3	-2.0	-1.3	1.7	3.9	7.0	9.7	4.4

Table 4 – First and last frosts of the season

Station	First 2.2^oC			First 0^oC			Last 0^oC			Las 2.2^oC			Av. frost-free period (days 2.2^oC+)
	1	2	3	1	2	3	1	2	3	1	2	3	
Beechworth	Apr 4	30	Jan 16	May 28	29	Mar 21	Sep 18	23	Nov 11	Nov 6	20	Dec 21	148
Myrtleford	Mar 19	29	Jan 8	Apr 29	16	Mar 1	Oct 21	29	Nov 23	Nov 11	12	Dec 10	127
Mount Buffalo	Jan 28	25	Jan 3	Mar 26	26	Jan 8	Nov 25	13	Dec 23	Dec 14	9	Dec 29	44
Hotham Heights	Jan 6	3	Jan 3	Jan 12	7	Jan 3	Dec 17	9	Dec 26	Dec 23	5	Dec 26	13

Note: 2.2^oC (36^oF) in the meteorological screen indicates a light frost at ground level.

Key:
1. Average date of first or last occurrence in the year (10-year period)
2. Mean deviation from average date (in days)
3. First or last recorded date of occurrence in the period

Source: Foley (1945)

Table 5 – Average saturation deficit 9 am (mm)

Station	No. of years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Wangaratta	32	13.1	12.3	8.7	4.8	2.3	1.3	1.4	2.0	3.7	5.9	9.1	12.1	6.4
Beechworth	30	10.3	10.2	6.3	5.1	3.0	2.0	1.9	2.6	3.9	5.5	7.7	9.1	5.6
Mount Buffalo	21	5.5	5.4	4.1	2.6	2.0	1.3	1.0	1.3	1.9	2.7	3.6	4.3	3.0
Hotham Heights	6	3.7	3.4	2.4	1.4	1.3	0.7	0.5	0.5	0.8	1.7	2.3	2.3	1.8

Source: Central Planning Authority (1949)

Table 6 – Estimates of average evaporation (mm)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Wangaratta	275	258	183	101	48	27	29	42	78	124	191	254	1610
Beechworth	223	214	134	107	64	42	39	54	103	116	162	191	1449
Mount Buffalo	115	113	86	54	45	27	21	27	40	55	76	91	750
Hotham Heights	78	72	31	31	27	14	11	10	17	36	49	48	424

Frost data for a 10-year period (1930-39) for the four temperature-recording stations used are presented in Table 4. The general trend of increasing frostiness with increasing elevation is not as obvious from these data because of the higherthan-expected frost incidence at Myrtleford, caused by its particular topographic situation. For example, Wangaratta, which lies at about the same elevation and only 40 km to the north, has an average frost-free period of 235 days over the same period.

The extreme frostiness of the high country is well illustrated by the very brief average frost-free period (13 days) at Mount Hotham.

Humidity

The available humidity data allow no more than an indication of trends. Table 5 sets out average 9 a.m. saturation deficits for Hotham Heights, Mount Buffalo and Beechworth. The highest saturation deficits occur at Beechworth in all months and, in general, the Beechworth figures are three times those at Hotham Heights. Mount Buffalo has readings more or less intermediate between those two stations. It would be expected that, as a result of higher temperatures in the northern valleys, saturation deficits would be higher there than at Beechworth.

Evaporation

No data of measured evaporation are available for the study area, but application of the Prescott formula (E = 21 x av. 9 a.m. S.D˙.) has yielded the estimates of evaporation presented in Table 6.

Wind

No records of wind are available. On the high country, the shapes of trees and shrubs have been influenced by strong winds from a generally westerly direction and this is also indicated by the orientation of wind-sorted gravel and sand on erosion pavements. Occasionally severe wind storms cause damage to trees and property in the lower country in the north of the study area.

Climatic control of plant growth and water supply

The frequency of ‘effective’ rainfall data (listed in Table 2) maybe used to predict the average length of the growing season as affected by moisture availability. The first of a succession of months with a frequency of more than 50**%** indicates the general start of the growing season and the number of consecutive months with frequencies of more than 50% indicates its average length.

In most of the agricultural districts of the study area March is the first such month, and all months through to and including December (except at Beechworth) have a better than 50% chance of receiving ‘effective’ rainfall. Therefore a growing season of about 10 months may be expected in most of the valley agricultural areas with a frequency of better than 50%.

The values for Harrietville indicate a full 12-month growing season, in terms of rainfall, with minimum frequency of better than 60% and this may reflect growing conditions in the upper valley areas generally.

Extrapolation to the grazing and agricultural land at intermediate elevations, such as at Whitlands and Toombullup, would indicate a similar growing season largely uninterrupted by moisture deficiency. Areas with even higher rain-falls — such as Hotham Heights and Mount Buffalo — can therefore be expected to also have an average growing season of 12 months on the basis of moisture availability.

The ability of the soil to store water that plants can use is a consideration in assessing growth pat-terns. Soil depth and physical characteristics and the rooting depth of plants are important. The estimates of growing season based on frequency of occurrence of ‘effective’ rainfall are for pastures. Deeper-rooting species such as many of the native trees and shrubs may draw upon soil water that is not available to pastures and should have longer growing seasons accordingly.

Low temperatures may reduce or even prevent the growth of plants and therefore must be considered when assessing plant growth patterns. A simple guide is that plant growth is reduced in a month with mean temperatures below 10°C, and no significant plant growth will occur in a month with a mean below 5.5°C. Table 3 shows that, at both Beechworth and Myrtleford, low temperatures reduce plant growth during June, July and August, but are not low enough to prevent it entirely (on a monthly basis). At both centres both May and September are only just above the limit. Mount Buffalo has monthly means of less than 10°C from April through October, and temperatures in June, July and August are low enough to prevent plant growth entirely.

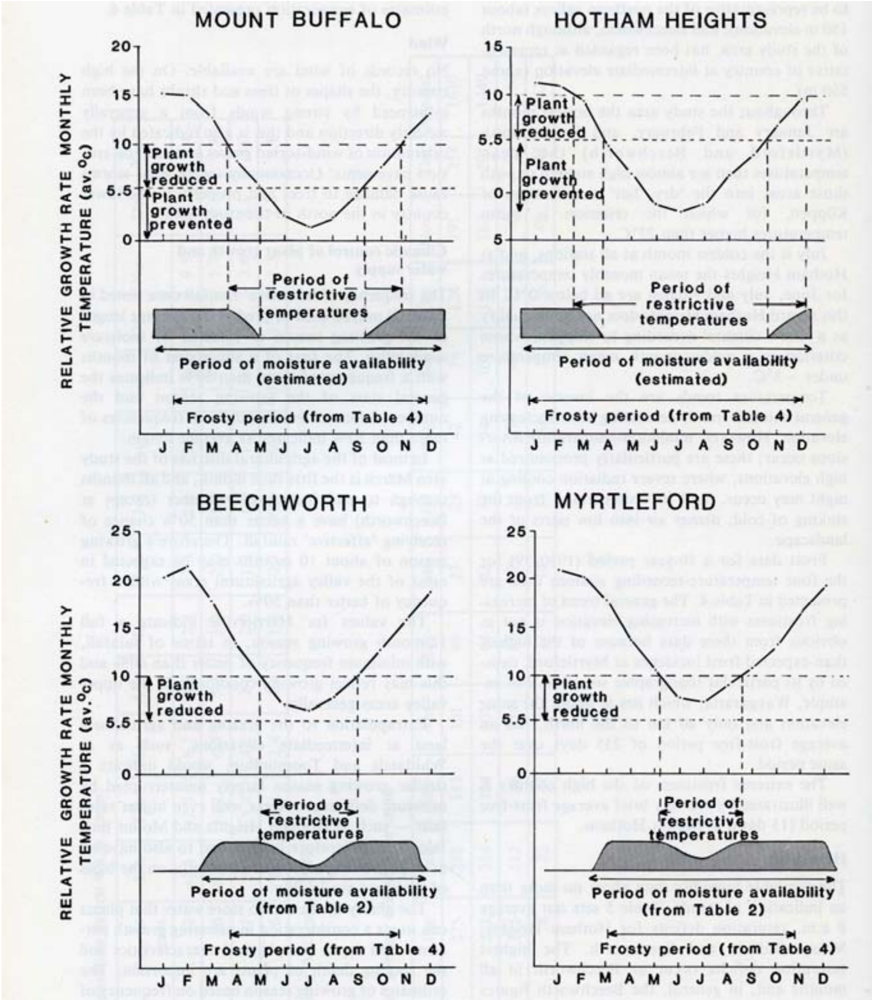

Figure 3 – The effect of climate on plant growth

Hotham Heights has an even more restrictive temperature regime, with growth being reduced from March through December and prevented from April through October.

The comments would only apply to those plants that are not susceptible to frost damage. Table 4 shows that frosts occur over even longer spans of the year at all the localities considered and these dates will be of more relevance to frost-sensitive species.

Table 7 – Potential stream flow contributed by various parts of the catchment

Range of elevations	Potential run-off (ML per km^2)	Catchment area* (%)	Potential contribution to stream flow as a percentage of potential total yield (%)
Below 300 m	660	15	4.0
300 – 900 m	2160	70	60.3
900 -1500 m	5810	14	32.4
Over 1500 m	8230	1	3.3

Figure 3 presents plant growth patterns resulting from limitations of moisture and temperature (and based on the data presented in Tables 2, 3 and 4) for Myrtleford, Beechworth, Mount Buffalo and Hotham Heights.

The climate influences the quantity of water yielded by the catchment and the rate of yield. Although to a large extent total yield of water is closely related to total precipitation, the relation between the availability and utilisation of moisture also influences total yield. In this area losses through evapotranspiration are greatest in summer and least in winter. As a high proportion of the total precipitation also occurs in winter, the yield of water at that time is relatively high.

Precipitation that falls as snow and forms drifts results in the storage of water. In this catchment snow falls on the higher areas in the winter, and most of it has melted by early summer. Thus a relatively high proportion of precipitation in these areas becomes available as run-off.

In general, the higher parts of the catchment — because of their combination of lower evapotranspiration and higher rainfall — provide greater quantities of water for stream flow than the lower country. The data presented in Table 7 demonstrate their relative importance for water supply. The potential run-off data were obtained by calculating water budgets for country within the stated elevations.