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VARIATION IN AIR AND SOIL TEMPERATURES IN FOREST COMMUNITIES ON THE H.J. ANDREWS EXPERIMENTAL FOREST, 1970-1972

D. B. Zobel, W. A. McKee, G. M. Hawk, and C. T. Dyrness

Oregon State University and
USDA Forest Service, Corvallis

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ABSTRACT

Air temperatures at 1 m and soil temperatures at 20 cm are reported for twenty-one forest stands in the central Western Cascades of Oregon. Records began in 1970 for some stands, in 1971 or 1972 for most. Temperature Growth Index for a stand, based on temperature effects on Douglas-fir seedling growth, varies from 32 to 101, and ordinates the stands similarly for 1971 and 1972. However, the index is not closely related to stand position in a vegetation ordination. A strong nocturnal temperature inversion causes summer minima to <u>increase</u> with elevation up to 1100 m. All lapse rates are low up to 1100 m. Comparisons with studies of montane forests in Arizona and Colorado show that the sites studied here lack the temperature variation, particularly the low minima, characteristic of the other areas.

INTRODUCTION

In the vicinity of the H. J. Andrews Experimental Forest in the Western Cascades of Oregon, twenty-three plant communities have been described (Dyrness *et al*., 1973). These communities have been analyzed by an ordination technique. The resulting classification of communities provides a useful and sensitive method of stratifying the landscape in the Experimental Forest for sampling and modeling of ecosystem structure and processes. However, measurements of environment and observations of plant phenology in these communities will make such a stratification more useful and provide some insight into the environmental situation represented by different communities. To obtain such measurements, "reference stands" were established in stands representing approximately the modal conditions in each of several widespread or contrasting plant communities.

The relationship of plant moisture stress to plant communities on the Andrews is reported by Zobel et al. (1973). Another major determinant of community distribution in Oregon vegetation is temperature (Waring 1969) and important variation within the vegetation on the H. J. Andrews appears to be associated with temperature conditions (Dryness et al. 1973).

This paper reports the temperatures measured and briefly discusses some of the relationships of temperature with elevation and plant communities. Brief comparisons with similar measurements elsewhere in Western coniferous forests are made.

METHODS

Thermographs were installed in "Reference Stands" (RS) representing the plant communities and at the times outlined in Table 1 Their general locations are shown in Fig. 1. Within each reference stand, a spot closely resembling the average conditions for that type of community was chosen. A Partlow two-pen thermograph, using a 30- or 31-day circular chart, was installed at each location. The air temperature probe was protected under an insulated A-frame shield at 1 m above the ground, and the soil probe was buried 20 cm deep. With each chart change (every 3 to 4 weeks except in winter) the soil and air temperature were checked with a standard thermometer, and any discrepancy recorded. If the difference was 2 F or greater, the thermograph pen was adjusted.

Table 1. Forest Community, Elevation, Slope, Aspect and Date of Installation of Each Reference Stand

Ref. Stand	Forest Community	Abbreviation	Elevation (m)	Aspect	Slope (deg)	Date
1	Pseudotsuga menziesii/Holodiscus discolor	Psme/Hodi	490	S40W	30	April 7[illegible]
2,17	Tsuga heterophylla/Rhododendron macrophyllum/Berberis nervosa	Tshe/Rhma/Bene	490,490	N70W,N20W	21,14	May 70 June 72
3	Tsuga heterophylla - Abies amabilis/Linnaea borealis	Tshe-Abam/Libo	945	S85W	5	April 7[illegible]
4	Abies amabilis/Tiarella unifoliata	Abam/Tiun	1310	N54W	20	June 70
5	Tsuga heterophylla - Abies amabilis/Rhododendron macrophyllum/Berberis nervosa	Tshe-Abam/Rhma/Bene	880	--	level	May 71
6,16	Tsuga heterophylla/Castanopsis chrysophylla	Tshe/Cach	610,640	S25W,S40W	30,35	*April [illegible] April [illegible] [illegible]
7	Tsuga heterophylla/Polystichum munitum - Oxalis oregana	Tshe/Pomu-Oxor	460	N30W	29	May 71
8	Pseudotsuga menziesii - Tsuga heterophylla/Corylus cornuta var. californica	Psme-Tshe/Cococa	490	S85W	39	April [illegible]
9	Tsuga heterophylla/Acer circinatum/Polystichum munitum	Tshe/Acci/Pomu	460	N50W	41	April [illegible]
10	Tsuga heterophylla/Rhododendron macrophyllum/Gaultheria shallon	Tshe/Rhma/Gash	610	--	level	April [illegible]
11	Pseudotsuga menziesii/Acer circinatum/Berberis nervosa	Psme/Acci/Bene	1010	S20W	11	May 71
12	Abies amabilis/Vaccinium alaskense/Cornus canadensis	Abam/Vaal/Coca	1010	S40W	8	July 71
13	Abies procera/Clintonia uniflora	Abpr/Clun	1310	S20W	23	Aug 71

Table 1 (cont.):

Ref. Stand	Forest Community	Abbreviation	Elevation (m)	Aspect	Slope (deg)	Date
14	Abies amabilis - Tsuga mertensiana/ Xerophyllum tenax	Abam-Tsme/ Xete	1430	N33W	27	Aug 71
15	Tsuga heterophylla/Polystichum munitum	Tshe/Pomu	760	N10W	33	*May 70 July 72
18	Pseudotsuga menziesii/Acer circinatum/ Whipplea modesta	Psme/Acci/ Whmo	1100			June 72
19	Pseudotsuga menziesii/Polystichum munitum	Psme/Pomu	378	E	26	July 72
DELTA	[a]Pseudotsuga menziesii/Corylus cornuta-Symphoricarpos mollis/Polystichum munitum	Psme/Coco-Symo/ Pomu	350	-	Flat	April 70
LOOKOUT	Not named: Pseudotsuga menziesii and Abies grandis are dominant	---	1370	S60E	35	April 70

a) From Hawk (1973)

* In 1970, the types represented by RS6 and 15 were sampled in other locations. These data are indicated as RS *6 and RS *15, and are marked with an asterisk throughout the report.

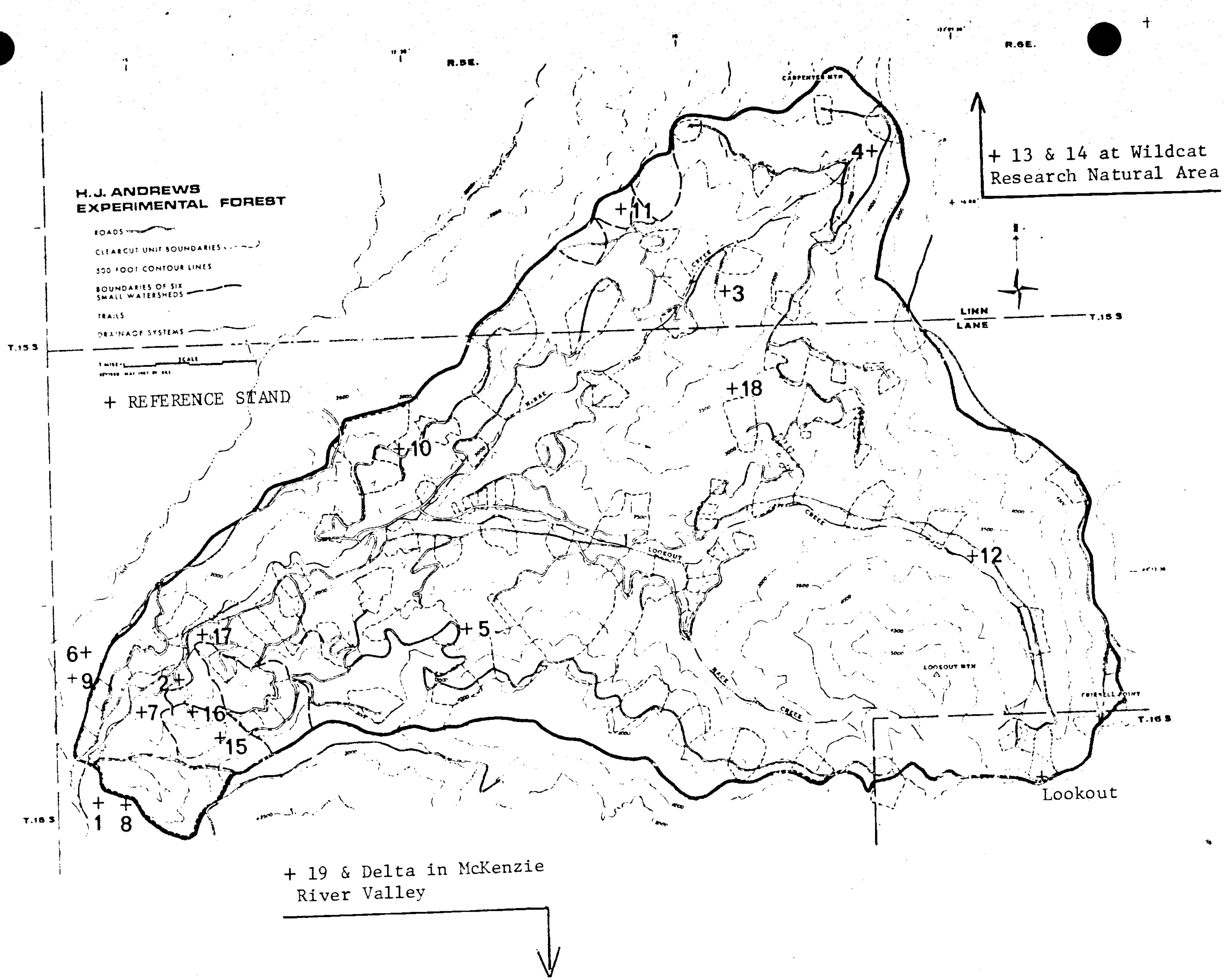

Fig. 1. Location of reference stands on the H. J. Andrews Experimental Forest.

Data from two other stands in the same area, being used in another study (Zobel, unpublished data), are included to add perspective to the RS data. DELTA is on a valley-bottom terrace near the McKenzie River, and LOOKOUT is in a young stand of Pseudotsuga and Abies grandis on an E slope directly above the McKenzie River Valley (Table 1). Data were collected and analyzed as with the RS data.

Thermographs were not serviced regularly during the winter of 1970-71. During 1971-72 and 72-73, charts were changed as regularly as conditions permitted. Because of heavy snowpack, 4-5 m in some stands, upper elevation air probe shelters were suspended 3.5-5 m above the ground and 2.6 m from a large tree during the dates shown in Table 2.

Thermograph charts were digitized and day and night means for air temperature were computed for each day as described by Cleary and Waring (1969), with the daylength defined for the H. J. Andrews Forest (Table 3). Mean daily soil temperatures were extracted from the charts manually.

Monthly means were calculated for soil temperature and for the following aspects of air temperature: day and night means, maximum and minimum, and daily range. Monthly extremes were determined for air and soil temperatures. Months with more than five days missing are not included in this compilation.

Monthly means were corrected in cases where the discrepancy between the chart temperature and the standard thermometer averaged 1.0 F or more for both ends of the record.

Using average day air temperatures and soil temperatures, a Temperature Growth Index (TGI) was computed for each site for each day during the "growing season". TGI, which weights temperature data according to its effect on growth of seedlings of Pseudotsuga menziesii in growth room conditions, was computed

Table 2. Dates and heights of elevation of air temperature sensors in higher elevation reference stands.

Ref. Stand	Height (m)	Dates of Elevation 1971-72	1972-73
3	3.5	24 Nov. - 18 Apr.	10 Nov. -
4	4.5	23 Nov. - 25 May	6 Nov. -
5	4.5	23 Nov. - 20 Apr.	None
10	4.5	23 Nov. - 20 Apr.	None
12	3.5	18 Nov. - 8 May	6 Nov. -
13	5.0	1 Dec. - 21 June	6 Nov. -
14	5.0	1 Dec. - 21 June	6 Nov. -

Table 3. Time of sunrise and sunset and daylength, 15th of each month, for the H. J. Andrews Experimental Forest, Lat 44° 15'N, Long 122° 15', (Pacific Standard Time) (Data for 1966 from U.S. Naval Observ. 1946).

Month	Time of (hr:min) Sunrise	Sunset	Daylength (hr:min)
Jan	7:42	16:56	9:14
Feb	7:09	17:38	10:29
Mar	6:22	18:15	11:53
Apr	5:26	18:53	13:27
May	4:42	19:29	14:47
Jun	4:24	19:54	15:30
Jul	4:39	19:51	15:12
Aug	5:11	19:15	14:04
Sep	5:48	18:20	12:32
Oct	6:23	17:26	11:03
Nov	7:05	16:42	9:37
Dec	7:38	16:31	8:53

as in Cleary and Waring (1969). (TGI is the same index as their Optimum Temperature Days, under a new name.) The "growing season" began with bud break of the dominant understory conifers at each site and ended with the date of the second frost. Attempts to determine the end of cambial growth (Wolter, 1968; Cleary and Waring, 1969) resulted in data too fragmentary and equivocal to define the end of the growing season.

RESULTS

Daily Means and Continuous Records:

These are available from the senior author for the cost of reproduction, as tables (daily means) or charts, for months for which averages are listed in Appendix A. They are also available for certain other periods for which data are too fragmentary to average.

Summary Measures:

Monthly averages for each RS are given in Appendix A. In Fig. 2 to 7, monthly averages are plotted for four contrasting stands spanning most of the variation encountered.

Extreme annual temperatures are given in Table 4, dates of last spring and first fall occurrence of 32 F and 20 F are in Table 5, and length of season with soil at or below 32F is in Table 6. Temperature Growth Index (TGI), with the summation period, is listed for 1971 and 1972 in Table 7.

DISCUSSION

Temperature Growth Index:

Use of the TGI accentuates the differences between sites seen in mean temperatures. There is relatively more variation within elevational zones and the overall rate of decline with elevation is considerably greater than

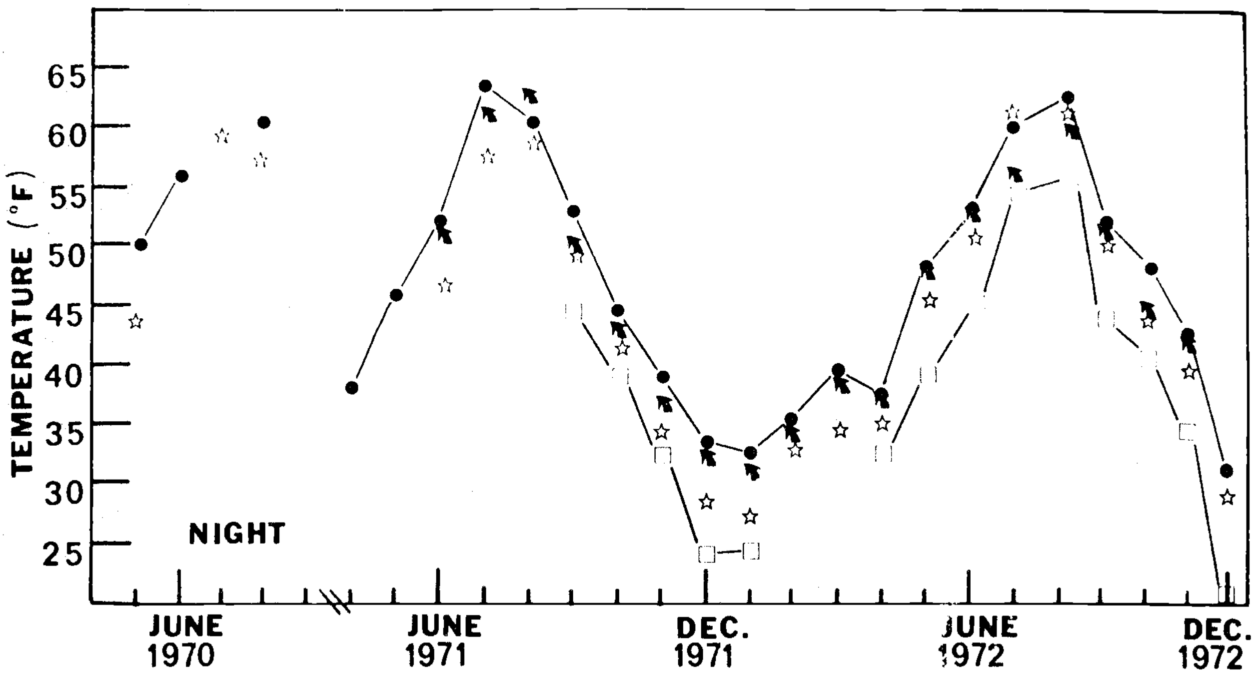

Fig. 2. Monthly mean night air temperatures at reference stands 1,3,7 and 14. Dots=RS1, Arrows=RS7, Stars=RS3 and Squares=RS14.

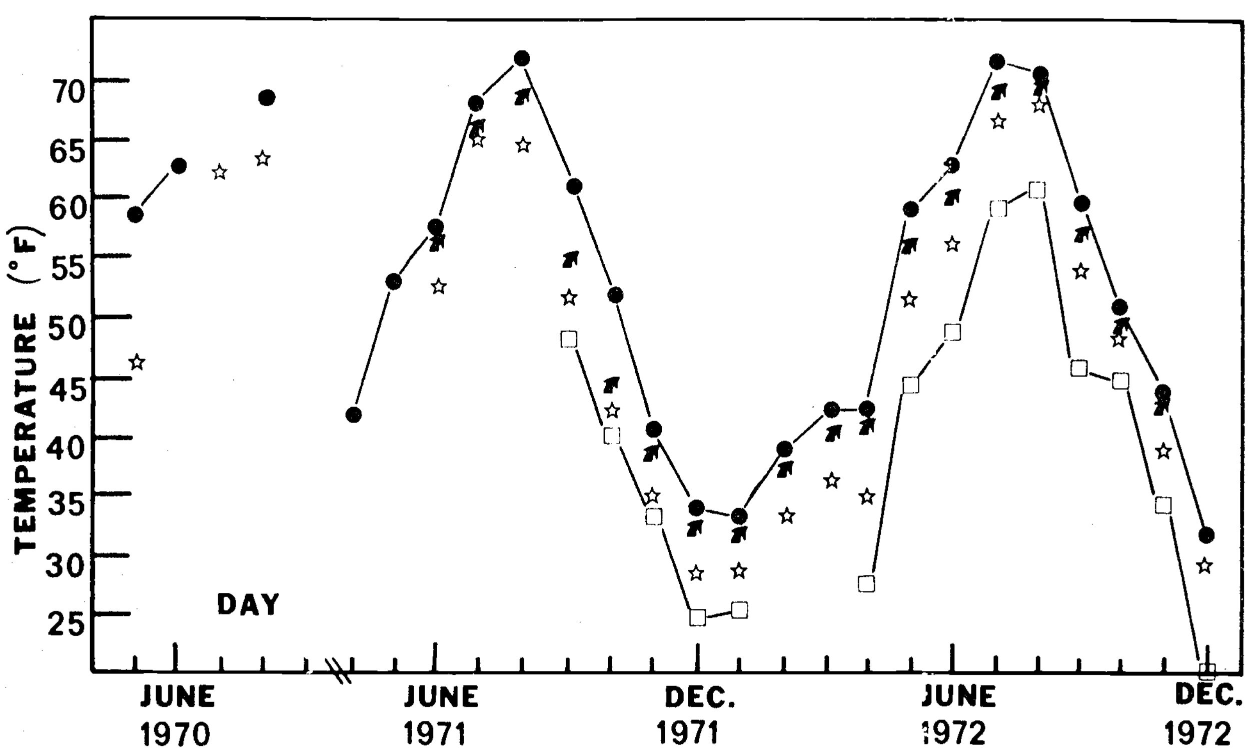

Fig. 3. Monthly mean day air temperatures at reference stands 1,3,7 and 14. Dots=RS1, Arrows=RS7, Stars=RS3, and Squares=RS14.

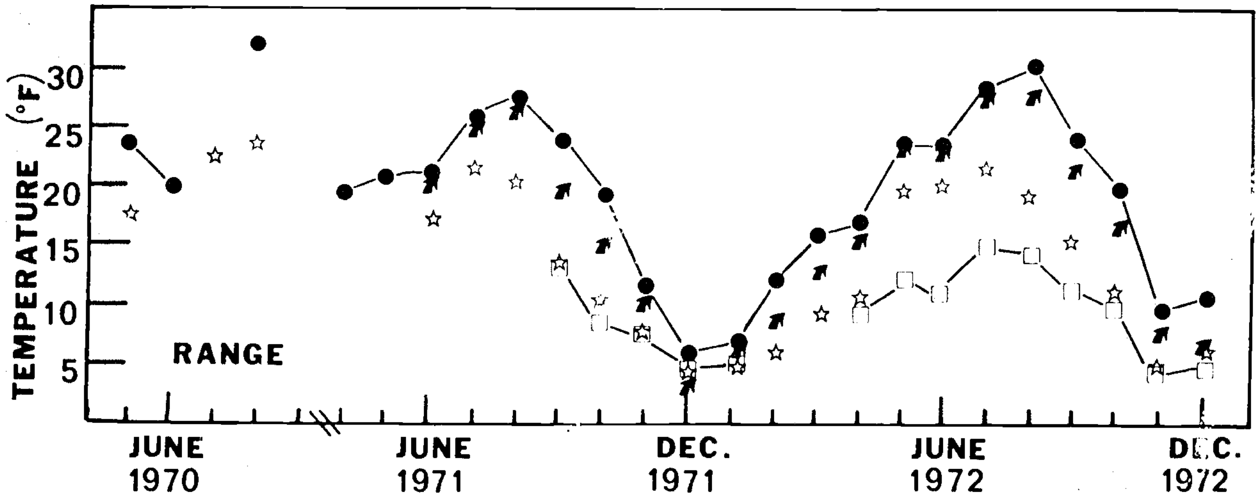

Fig. 4. Monthly mean of daily air temperature range at reference stands 1,3,7 and 14. Dots=RS1, Arrows=RS7, Stars=RS3, and Squares=RS14.

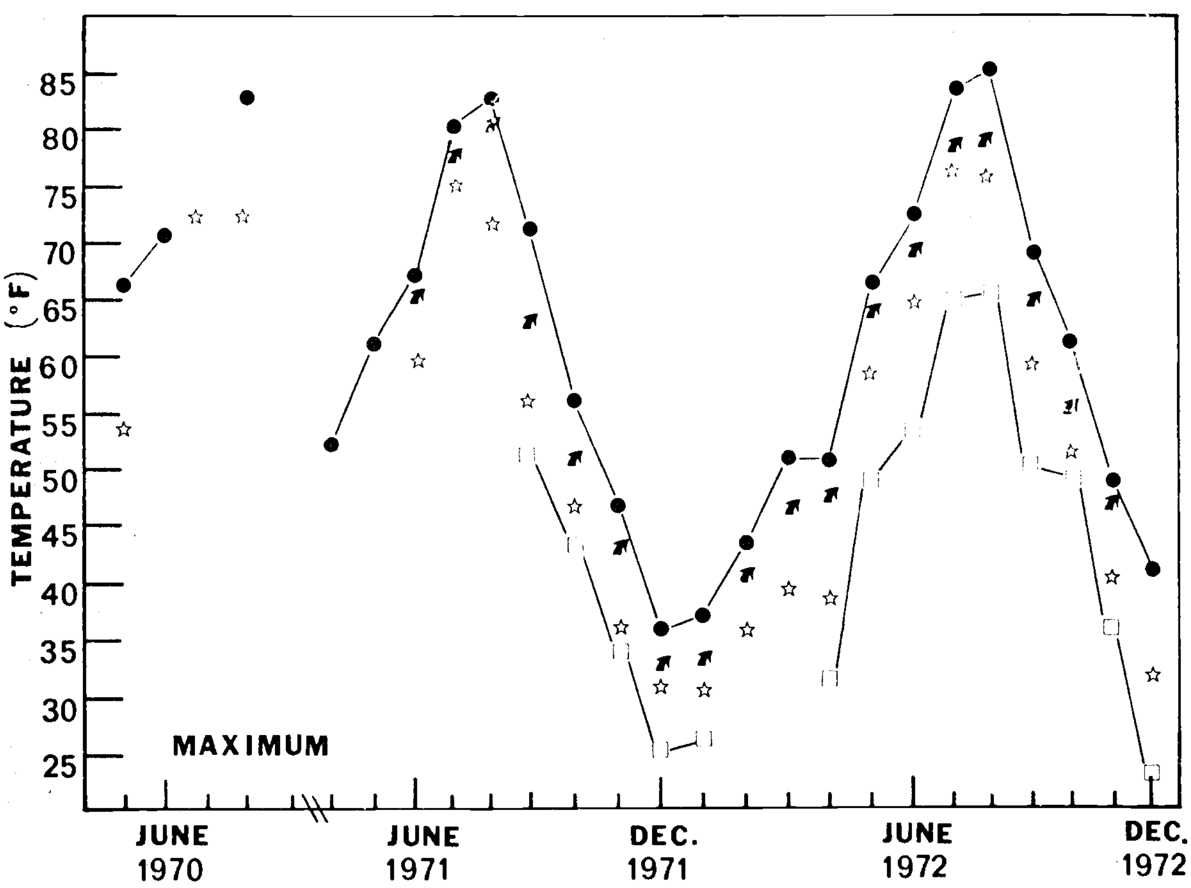

Fig. 5. Monthly mean maximum air temperatures at reference stands 1,3,7 and 14. Dots=RS1, Arrows=RS7, Stars=RS3 and Squares=RS14.

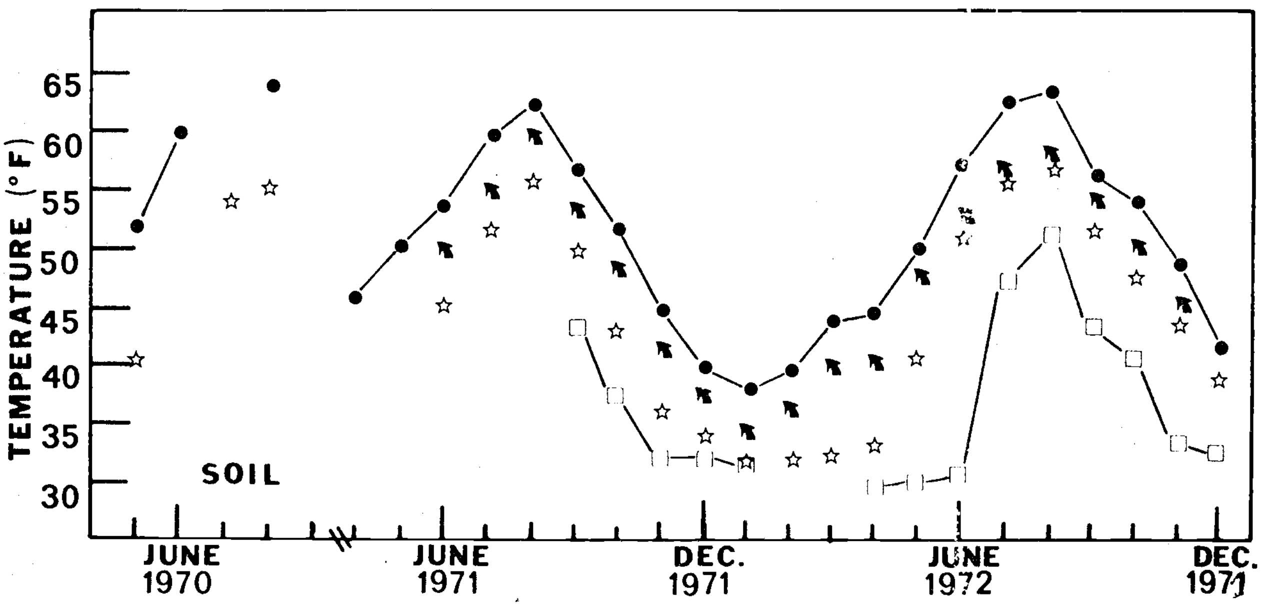

Fig. 6. Monthly mean soil temperature at reference stands 1,3,7 and 14. Dots=RS1, Arrows=RS7, Stars=RS3 and Squares=RS14.

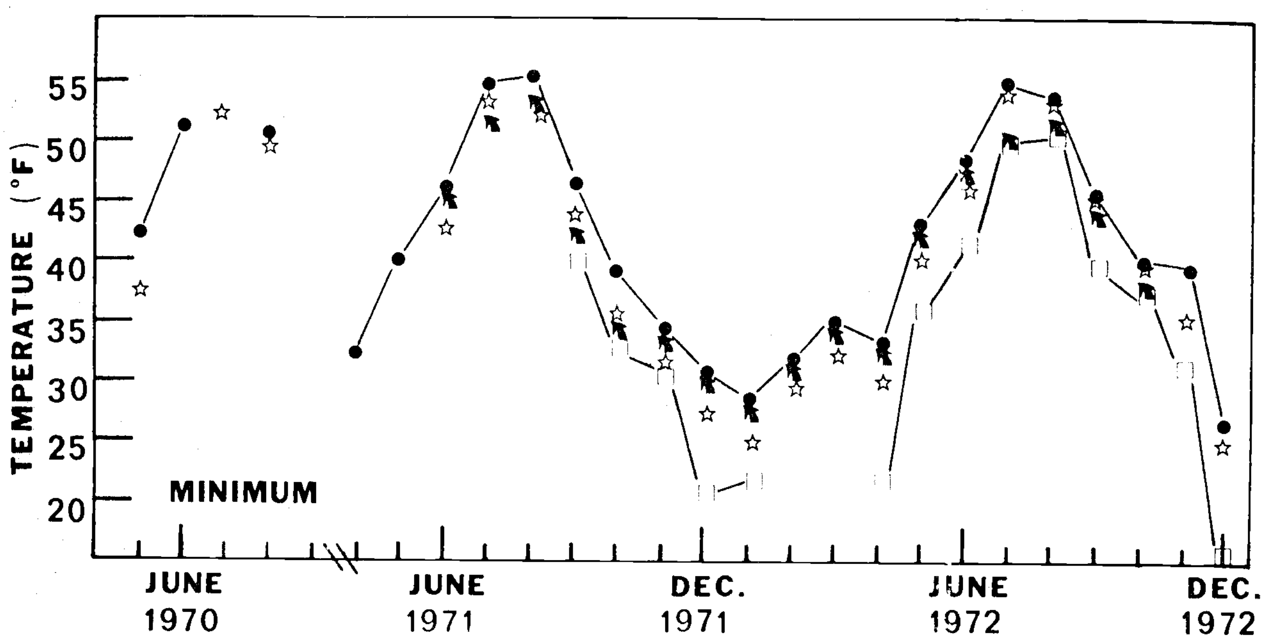

Fig. 7. Monthly mean minimum air temperatures at reference stands 1,3,7 and 14. Dots=RS1, Arrows=RS7, Stars=RS3 and Squares=RS14.

Table 4. Annual Maximum and Minimum Air and Soil Temperatures. Minimum values in parentheses are based on the last 6 mo. of the year only.

SITE	AIR					SOIL				
	Maximum			Minimum		Maximum			Minimum	
	1970	1971	1972	1971	1972	1970	1971	1972	1971	1972
1	98	104	109	(21)	+1	65	65	68	(37)	36
2	94	100	104	(20)	-4	58	60	64	(33)	32
3	91	94	100	(18)	0	56	58	61	(32)	31
4	85	91	93	(15)	-7	55	58	59	(33)	32
5		92	97	(21)	0		61	60	(34)	33
6	*107	99	105	(19)	-1	*62	63	65	(35)	34
7		99	102	(20)	0		62	62	(35)	33
8		101	104	(22)	0		66	67	(36)	34
9		99	105	(19)	-4		63	62	(36)	34
10		98	101	(18)	+1		61	64	(33)	32
11		99	102	(20)	-2		65	65	(34)	32
12		92	94	(19)	+2		59	58	(32)	31
13			90	(14)	-6			61	(32)	32
14			89	(13)	-8			59	(32)	30
15	* 89		98		+3	*59		66		(35)
16			105		+2			66		(37)
17			99		-3			61		(34)
18			100		-2			61		
19			92		+3			62		(37)

Table 4 (con't):

SITE	AIR					SOIL				
	Maximum			Minimum		Maximum			Minimum	
	1970	1971	1972	1971	1972	1970	1971	1972	1971	1972
DELTA	97	96	103	(21)	+1	62	64	65	(34)	32
LOOKOUT	85	92	97	(15)	-6	60	62	64	(34)	34

Table 5: Last spring and first fall occurrences of $32^{o}F$ and $20^{o}F$ air temperatures, and length of season between. N.O. = did not occur. M = no data.

	32°F									20°F			
SITE	1970			1971			1972			1971	1972		
	Spring	Fall	DAYS	Spring	Fall	DAYS	Spring	Fall	DAYS	Fall	Spring	Fall	DAYS
1	M	25 Oct	-	27 Apr	15 Oct	171	30 Apr	28 Oct	181	N.O.	2 Feb	4 Dec	305
2	M	13 Sep	-	18 May	15 Oct	150	30 Apr	28 Oct	181	27 Dec	2 Feb	4 Dec	305
3	13 May	7 Oct	147	M	14 Oct	-	23 May	26 Oct	157	7 Dec	2 Feb	3 Dec	304
4	M	9 Sep	-	M	25 Sep	-	10 June	22 Sep	104	27 Oct	26 Mar	3 Dec	252
5	M	M	-	30 May	28 Sep	121	24 May	27 Oct	157	N.O.	2 Feb.	3 Dec	304
6	*11 May	*25 Oct	*167	24 Apr	15 Oct	174	30 Apr	26 Sept	150	27 Dec	2 Feb	3 Dec	304
7	M	M	-	M	15 Oct	-	30 Apr	28 Oct	181	27 Dec	2 Feb	5 Dec	306
8	M	M	-	M	15 Oct	-	30 Apr	29 Oct	182	N.O.	2 Feb	3 Dec	304
9	M	M	-	M	15 Oct	-	30 Apr	29 Oct	182	27 Dec	2 Feb	3 Dec	304
10	M	M	-	M	14 Oct	-	1 May	28 Oct	180	27 Dec	2 Feb	3 Dec	304
11	M	M	-	31 May	16 Oct	138	30 Apr	24 Sep	146	6 Dec	M	3 Dec	-
12	M	M	-	M	14 Oct	-	24 May	23 Sep	122	28 Oct	1 Feb	3 Dec	305
13	M	M	-	M	25 Sep	-	11 June	9 Sep	90	27 Oct	29 Apr	3 Dec	218
14	M	M	-	M	25 Sep	-	11 June	9 Sep	90	27 Oct	29 Apr	3 Dec	218
15	*11 May	*22 Nov	*195	M	M	-	M	28 Oct	-		M	3 Dec	-
16							M	29 Oct	-		M	3 Dec	-
17							M	26 Sep	-		M	3 Dec	-
18							M	23 Sep	-		M	3 Dec	-
19							M	M	-		M	4 Dec	-
DELTA	27 Apr	13 Sep	138	19 Apr	16 Oct	179	30 Apr	28 Oct	181	N.O.	2 Feb	4 Dec	305
LOOKOUT	29 Jun	12 Sep	75	28 Jun	25 Sep	89	M	18 Sep	-	26 Oct	M	3 Dec	-

Table 6. Days with soil temperature (-20 cm) at 32°F or below. M = missing data, but >0. ( ) = estimated when few missing days.

SITE	1971	1972	
	Jul-Dec	Jan-Jun	Jul-Dec
2	0	8	0
3	14	125	0
4	0	M	0
10	0	31	0
11	0	M	0
12	31	132	0
13	(15)	122	0
14	53	(160)	0
DELTA	0	2	0

Table 7. Annual Temperature Growth Index (TGI) and the period of TGI summation for each year (bud break of understory conifers to date of second frost).

R.S.#	Veg Zone	1971 TGI (days)	1971 Summation Period Start	1971 Summation Period End	1971 Summation Period Days	1972 TGI (days)	1972 Summation Period Start	1972 Summation Period End	1972 Summation Period Days
1	Tshe	94.7	19 May	16 Oct	150	101.5	19 May	29 Oct	163
2	Tshe	74.1	4 Jun	16 Oct	134	84.0	7 Jun	29 Oct	144
3	Trans.	56.2	24 Jun	14 Oct	112	67.3	17 Jun	27 Oct	132
4	Abam	33.8	22 Jul	26 Sep	66	37.6	8 Jul	23 Sep	77
5	Trans.	59.6	10 Jun	29 Sep	111	70.4	10 Jun	28 Oct	141
6	Tshe	84.5	23 May	16 Oct	146	93.4	28 May	28 Oct	153
7	Tshe	80.3	27 May	16 Oct	142	82.3	31 May	29 Oct	151
8	Tshe	89.5	19 May	15 Oct	149	97.9	23 May	30 Oct	160
9	Tshe	81.1	4 Jun	16 Oct	134	86.5	31 May	30 Oct	152
10	Tshe	76.0	28 May	15 Oct	142	82.9	31 May	29 Oct	151
11	Tshe	73.3	10 Jun	16 Oct	128	78.3	8 June	26 Oct	140
12	Abam	39.8	5 Jul	29 Sep	86	48.7	21 Jun	24 Sep	95
13	Abam					36.7	7 Jul	18 Sep	73
14	Abam					31.9	13 Jul	18 Sep	67
DELTA		93.3	2 May	17 Oct	168				
LOOKOUT		51.3	13 Jun	25 Sep	104				

any lapse rate for mean temperatures. However, the ordination of stands using TGI was essentially the same in 1971 and 1972. The only reversal of positions in the ordering was within RS 2, 10 and 7, which were very close in 1972.

TGI ordination does not correspond particularly well with either the X- or the Y-axes of the vegetation ordination developed for the Tsuga heterophylla and transition zones (Dyrness et al., 1973). There is correlation over parts of both axes, but for about half the stands TGI and axis position are uncorrelated. Position on the Y-axis correlates partially with foliage nutrient content, but for five stands we still have no explanation of the possible meaning of the vegetation ordination axis. The X-axis position is a good indicator of the maximum plant moisture stress encountered in the stands (Zobel, et al., 1973). However, the three vegetation zones are exclusively defined by TGI: Tsuga heterophylla; >73 in 1971 and >78 in 1972; Transition, 56-60, and 67-70; and Abies amabilis, <40 and <49.

A comparison of two-dimensional environmental space (TGI and plant moisture stress) occupied by forest stands sampled in the H. J. Andrews and in the eastern Siskiyou Mountains (Waring, 1969) is given in Fig. 8. Generally the portion of the potential environment occupied by sampled stands is about the same in both cases, and is only about half the area available within the rectangle described by the ranges of TGI and moisture stress. Low water stress environments were not sampled above 90 TGI, nor were high moisture stress environments found at low TGI. Both of these studies sampled vegetation types of some regional importance, which indicated that the types of habitats not identified may indeed be uncommon. That such habitats do exist, however, is shown by the position of L', an open stand of non-zonal vegetation near LOOKOUT. The positions of DELTA and Waring's 15 bar-35 TGI

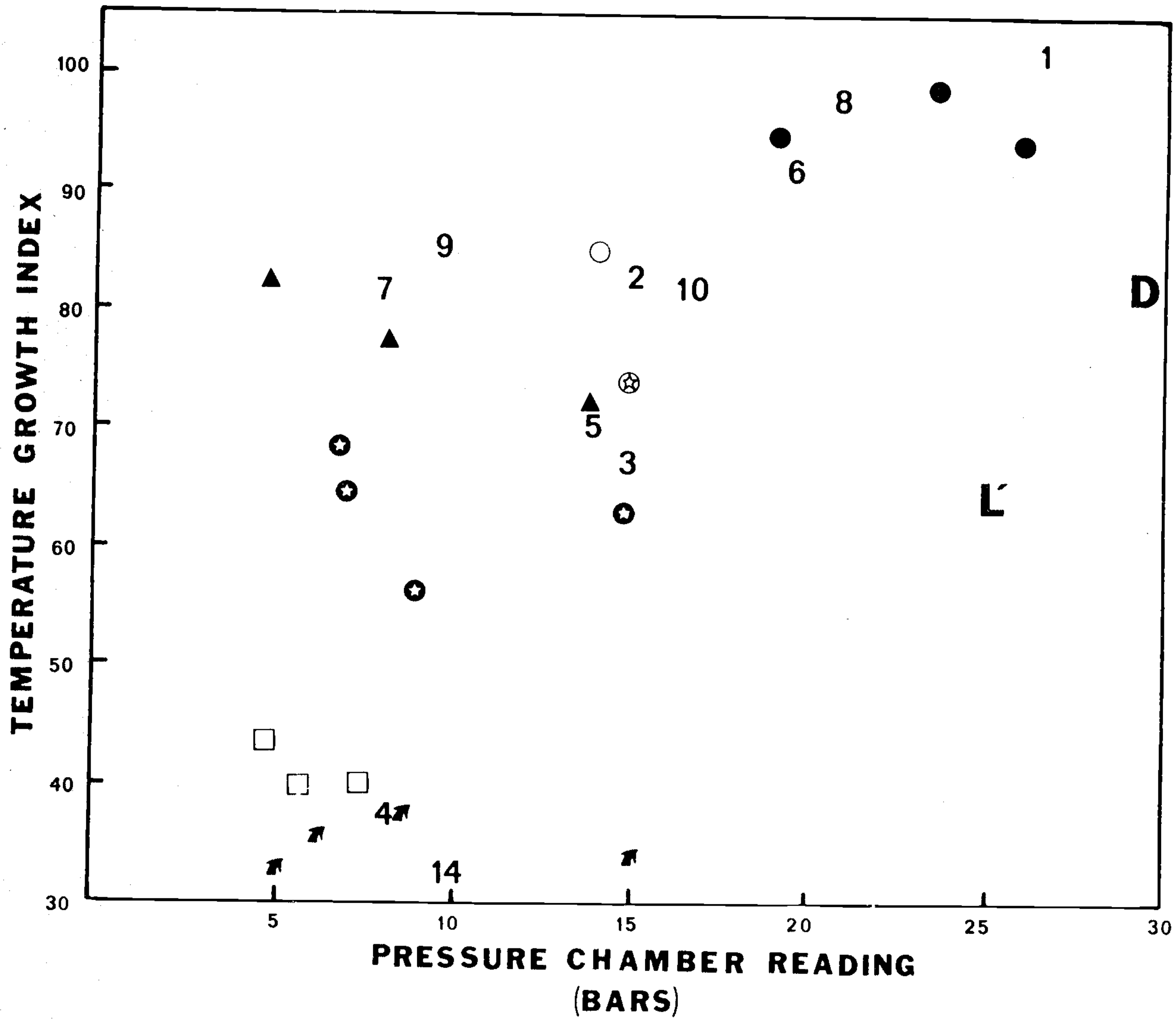

Fig. 8. Comparison of Temperature Growth Index and late season predawn plant moisture stress for forest communities in the central Western Cascades and in the eastern Siskiyous (From Waring, 1969).

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stand indicate that the limits of zonal forest may extend beyond the most frequently sampled area. However, that not all possible types of temperature-moisture combinations are important, or even present, seems clearly demonstrated.

Dyrness et al. (1973) conclude that "The location of the principal forest zones is largely a function of temperature... The distribution of individual communities within a zone is to a large extent controlled by the availability of moisture". Their former statement is well-supported by our data; the latter seems to be true for the Tsuga heterophylla zone, the only one for which more than two communities have been sampled for both moisture stress and temperature (Fig. 8).

Temperature Patterns in Time and Space:

For many sites and temperature means, the greatest month-to-month changes occur from June to July and from August to September, giving seasonal patterns a very distinct mid-summer peak. Whether the June-July change is usually this marked, or is peculiar to these two years of deep and late snowpack, awaits future sampling.

Another striking feature of the data presented is the "thermal belt" effect at mid-elevation stands. Here, the minima during the warmer months are high relative to low elevation stands: compare, for example, RS 3 at 945 m and 14 at 1430 m with RS 1 at 490 and RS 7 at 460 m in Fig. 2. Minima at RS 3 are higher than at RS 7 from July to October, and at 14 are equal to 7 in July and August. The average minimum in July, plotted over elevation for all stands, increases up to 1100 m (Fig. 9).

Minimum temperatures at all elevations have been quite moderate except for early December, 1972, when all-time record lows of -12 F occurred at Salem and Eugene in the Willamette Valley, and lows east of the Cascades were about -30 F. Even then the minima at all stands were above the valley

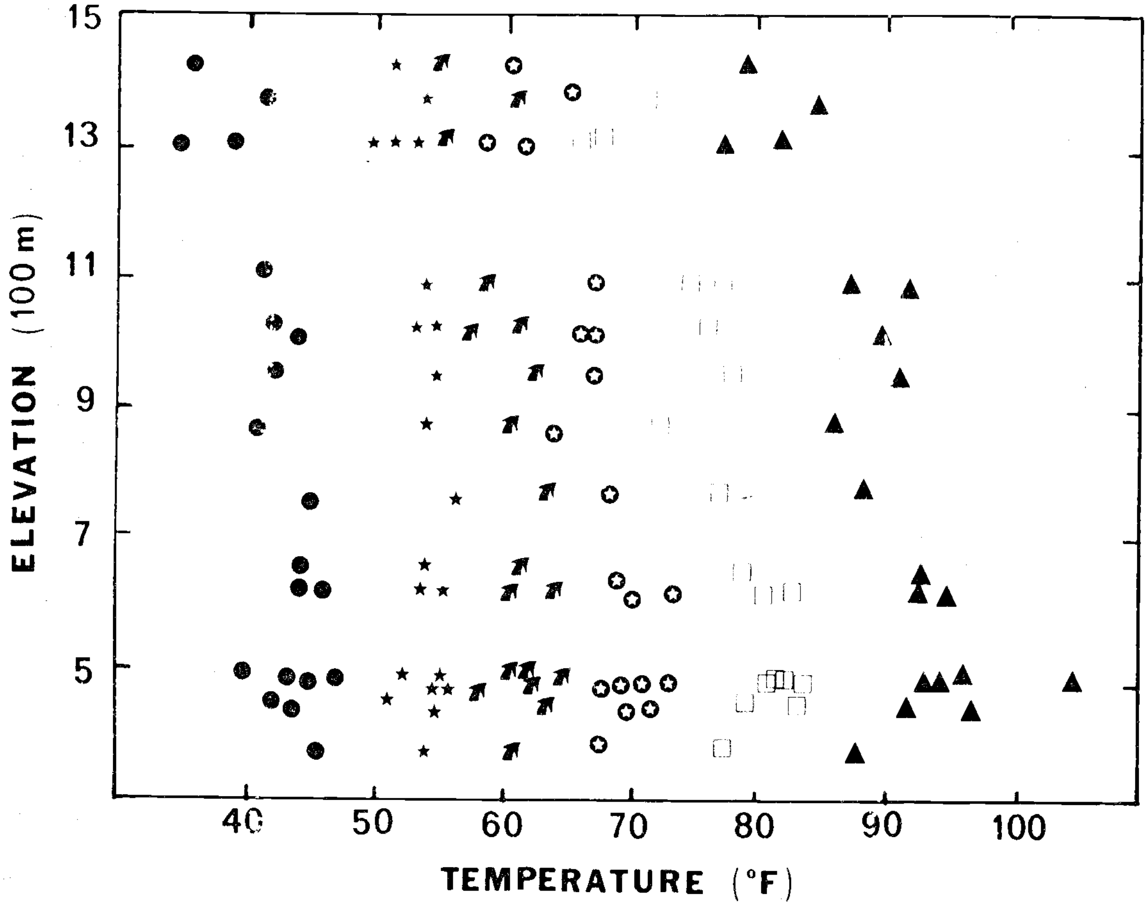

Fig. 9. Relationship of elevation to air temperatures at reference stands in July, 1972. Symbols, from left to right, represent the minimum, mean minimum, mean night, mean day, mean maximum, and maximum.

bottom lows and the -17 to -20 F recorded with equipment similar to our study at 1100 m on the east slope of the Cascades (Zobel, unpublished data). Some mid-elevation stands (RS 3,5,11,12,18) had higher minima than some at low elevations (RS 2,9) (Table 4). Average night temperatures in summer do decrease slightly with elevation, but more slowly than mean day or maximum temperatures (Fig. 9). Night means at RS 1 (Fig. 2) are sometimes exceeded during warmer months, most often by RS 6,8,9,11 and 15. Day means (Fig. 3) at RS 1 are exceeded occassionally by stands 2 and 8. Monthly day and night temperature means are lower than at RS 14 occasionally at RS 13 and only seldom at RS 12.

The different lapse rates for maximum and minimum temperatures result in a marked decrease in the July mean daily temperature range with elevation (-1.33 F/100 m). This difference in daily range is much smaller in the winter (Fig. 6). The daily range at RS 1 is usually the largest, but is sometimes exceeded in summer by RS 6 and 9.

The length of the frostless season appears to vary by a factor of about two (Table 5). However, autumn in 1972 was warm very late, except for an early September freeze at high elevations, perhaps accentuating the differences between high and low elevation stands.

Soil temperature shows its largest difference between stands in the spring due to a lag in high elevation snowmelt (Fig. 6). The July soil "lapse rate" is greater than that of day or night means. Rarely do monthly soil means exceed those at RS 1; no stands have had colder soil temperatures than RS 14. Only in a few stands does the soil fall to 32 F at the 20 cm level. Heavy snowpack insulates the soil and temperatures below 30 F have not been recorded even in the one long and the one cold winter sampled. However, where snowmelt is late, the soil may remain at 32 F for several months (Table 6).

The stands at DELTA and LOOKOUT were included because they represent topographic positions not sampled in the Andrews study, and they might be expected to vary outside the limits shown by the other stands. The DELTA stand, in the McKenzie River valley bottom, is slightly warmer than RS 1 in spring but is cooler in summer and fall. This site is influenced by the river and associated fogs, as well as getting maximum cold-air drainage during summer-fall temperature inversions. The site at LOOKOUT has summer-fall air temperatures about the same as the other high elevation sites. However, the soil temperature on this steep ESE slope exceeds that of RS 4, 13 and 14 by at least 2 F in summer and fall, the only months for which data are available.

Baker (1944) summarized data available from weather stations in the mountainous western U.S. He commented on the low July temperature lapse rate on the west slope of the Oregon Cascades, -0.75 F/100 m, compared to -1.15 for the region in general. Our data reinforce his conclusion, at least for the lower elevations. Lapse rates for the Andrews in July, 1972, were as follows for stands up to 1100 m: Minimum, +0.33 F/100 m; Night, -0.17; Day, -0.60; Maximum, -0.98; and Soil, -0.85. Lapse rates above 1100 m are considerably greater, based on the few data avilable.

Baker also notes a 32 F diurnal variation which changes little with elevation. Our summer diurnal variation approaches this only at some of the low elevation sites, perhaps due to the effect of the canopy in our sampling. However, it drops about 1.3 F/100 m over all elevations, rather than remaining constant as Baker concluded.

The summer temperature inversions found in this study may arise partially from cold-air drainage. Besides this, the inversions appear to be considerably influenced, especially in their more extreme form, by advection from the more arid region east of the Cascade crest. Advent of a steady, warm, dry east wind has been oserved during some summer nights, and sites exposed to this advection sometimes show a truncated nocturnal temperature decline associated with the arrival of dry air. An example for the LOOKOUT site is given in Fig. 10.

Comparisons with Other Studies:

Two studies of temperatures in natural vegetation in the mountainous west have been used for comparison with our data. Because data were taken by different means, and often in openings, whereas ours have been in forest of the usual density, and because the length and dates of study periods are much different, exact comparisons are impossible. However, some general differences in magnitude and pattern are evident.

Marr *et al*. (1968) give averages for 12 years collected in openings in ridgetop stands in three forest zones on the east slope of the Colorado Front Range: a) Lower montane (*Pinus ponderosa*) at 2200 m, b) Upper montane (*P. ponderosa*-*Pseudotsuga menziesii*) at 2600 m, and c) Subalpine (*Picea engelmannii*-*Abies lasiocarpa*) at 3050 m. Generally, there is much greater temperature variation than found on the H. J. Andrews sites. Specific comparisons of the Lower Montane zone with RS 1, and of the Subalpine zone with RS 14 will help illustrate differences. Colorado maxima are similar to RS 1 and 14, or higher in some months, especially June and December. However, minima are lower for Colorado sites, except at low elevations during the summer. Differences in winter minima are especially large. Lapse rates are generally higher in Colorado. Soil temperatures are warmer than on the Andrews in summer, but are colder during the winter (our 20 cm soil temperatures were compared with the average of the Colorado 6 and 12 inch readings).

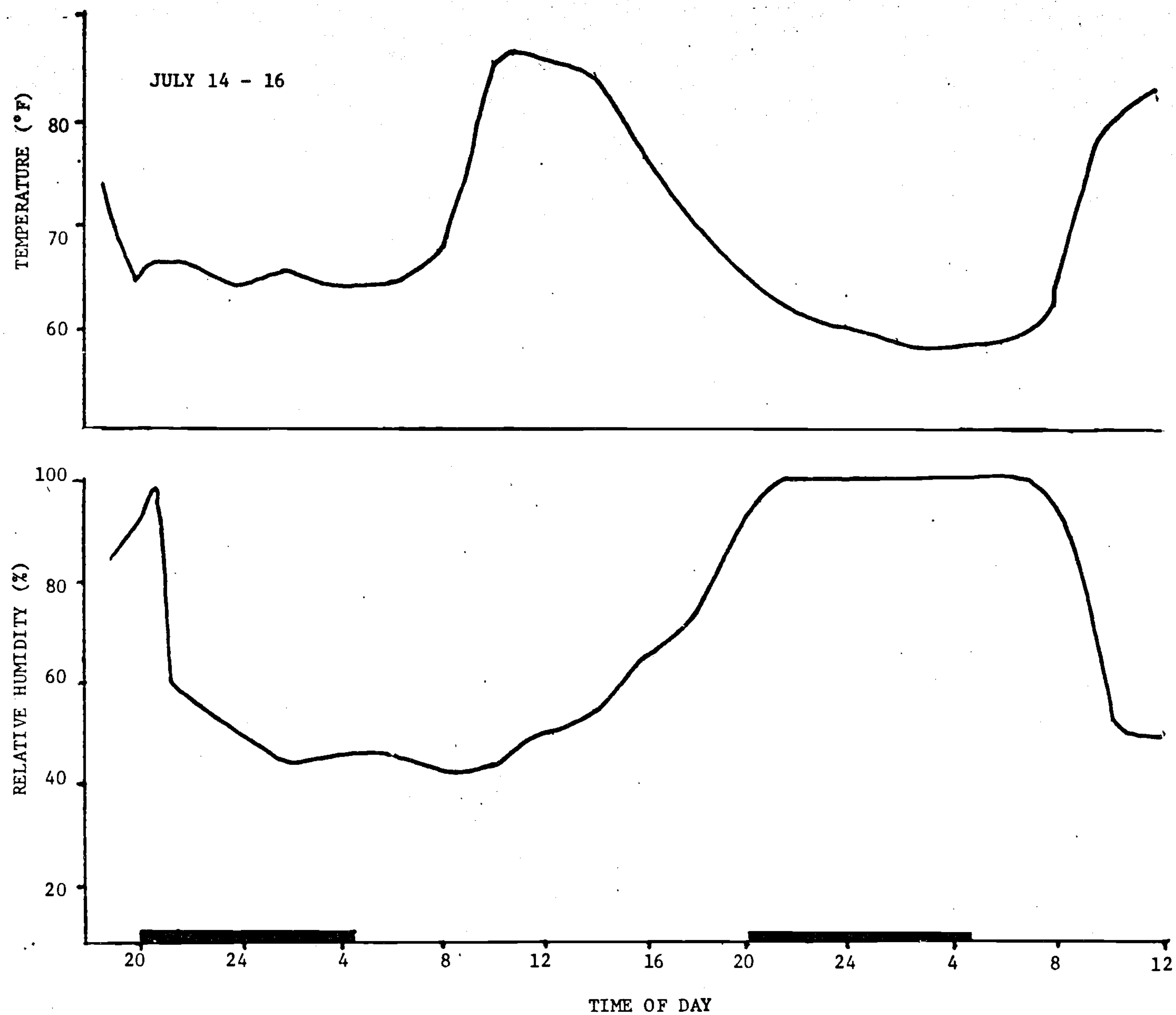

Fig. 10. Air temperatures and relative humidities for four nights in July, 1971, in an opening near the LOOKOUT site. On the first night of each pair, the humidity dropped about the same time as temperature levels off. Before dawn of the 15th a steady east wind was observed on the site, which is assumed to have caused the drop in humidity and the arrested decline in temperature. The second night is interpreted as being a "normal" pattern developing by radiative cooling in the absence of the east wind.

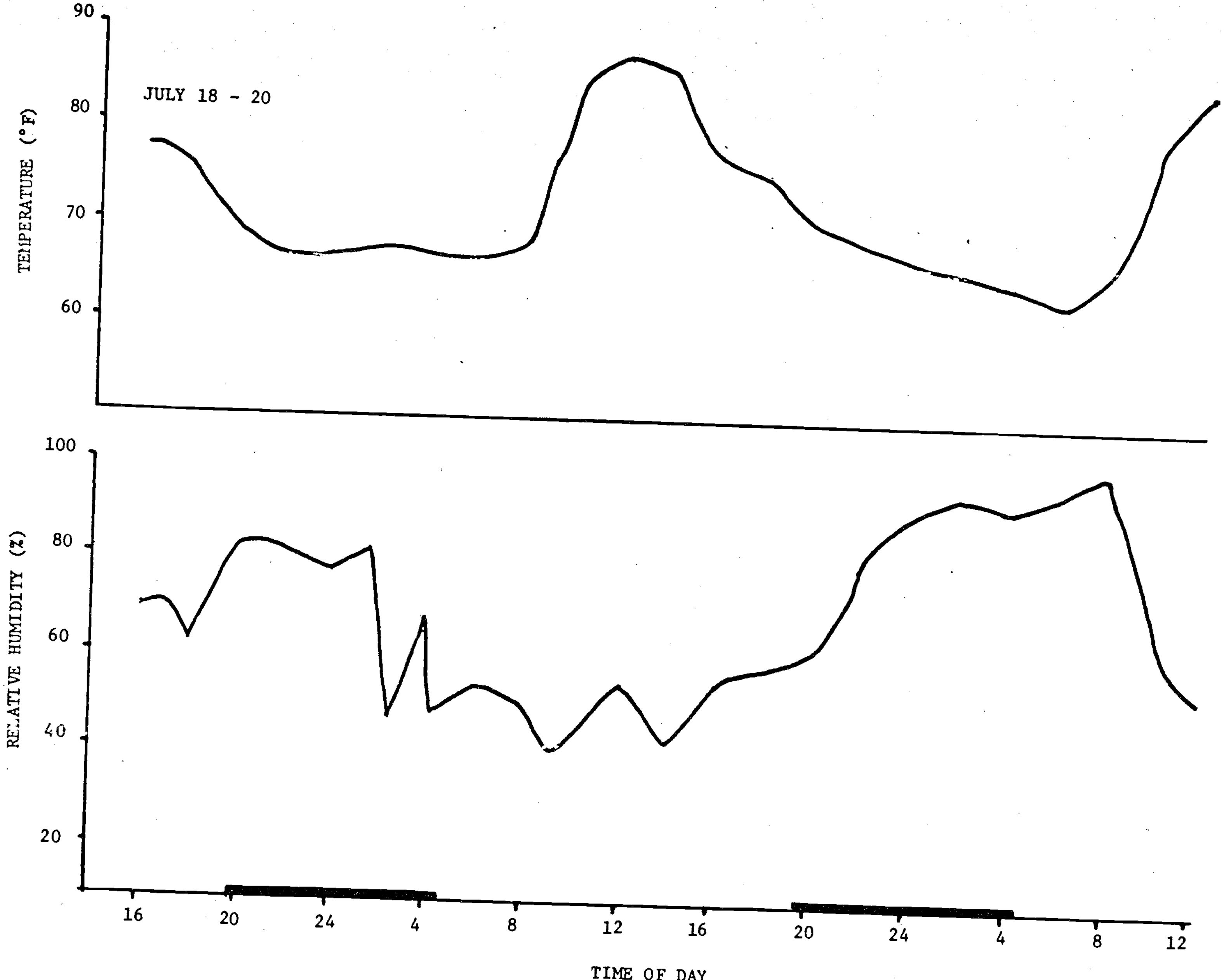
90
80
70
60
TEMPERATURE (°F)
JULY 18 - 20
100
80
60
40
20
RELATIVE HUMIDITY (%)
16
20
24
4
8
12
16
20
24
4
8
12
TIME OF DAY

Fig. 10 (Cont'd).

Pearson (1931) reports 1917 to 1919 temperatures from small forest openings for several forest zones on San Francisco Peak, Arizona. Of particular interest are his data from the following forest types: a) Western Yellow Pine at 2230 m, b) Douglas-fir at 2710 m, and c) Engelmann Spruce at 3200 m (see his Fig. 14). General comparisons with our data show several differences. Again, minima are much lower than on the Andrews; all Arizona zones mentioned above had lower monthly average minima than RS 14 did for six months in 1972. Temperatures of the Western Yellow Pine zone were compared to RS 1 and the Engelmann Spruce zone to RS 14. Maxima are similar in spring and fall, but on Arizona sites are lower in summer and higher in December. June is warmer than other summer months, a pattern also seen in some Weather Bureau data (Pearson, 1931, Fig. 15-17). This contrasts to the very marked July-August peak in our area. July maximum temperatures decreased with elevation in the Arizona study, but the minima showed a strong inversion pattern, similar to that on the Andrews. The Western Yellow Pine zone soil temperatures were below those of RS 1, except when similar in summer. Engelmann Spruce soil temperature was similar to RS 14, except lower in mid- to late winter.

Limitations of the Study:

Use of a single reference stand to represent most of the communities sampled, and sampling at a single location within each stand, presents some problems. Each sample- and subsample-of-one may misrepresent its particular community or stand, and we have few checks by replication to indicate this. We felt our limited resources would be more efficiently used in sampling sparingly throughout the range of vegetation types present than by intensive sampling within a few types. However, we did choose our stands to try to sample the modal vegetation conditions in each community, which should help to assure that environment of that stand does not misrepresent the overall conditions in the community. Two communities were replicated in July to December, 1972: RS 17 is the same as RS 2, and RS 16 the same as RS 6. For the six-month period, RS 17 has day temperatures 1.0 F (range of differences in monthly means were +1.7 to -3.3) below RS 2, while the night is only 0.3 F below (+1.2 to -1.8). Soil temperatures at 17 were consistantly below RS 2, the difference averaging 2.0 F (-0.6 to -3.1). The level of agreement between RS 16 and RS 6 is similar. Day means are 1.9 F lower at 16 (-0.6 to -3.1). Night and soil means are close, but the relationship between stands fluctuates considerably from month to month: at night, 16 is 0.2 higher (-3.2 to +2.1), while the soil is 0.5 F cooler (-1.6 to +0.2).

We plan to assess soil temperature variation within each RS in the summer of 1973.

Some stand temperatures may represent other than undisturbed vegetation, being located close enough to roads, clearcuts, etc. to possibly be influenced by them. The major problem of this type lies with RS 1 and 8, located above a reservoir which extends 150 m W and several km S and SW of the base of the slope. Drainage of this section of the reservoir has occurred at different times each summer since it was filled in 1969, probably changing its influence from moderating to intensifying temperature extremes in the area.

Differences in temperature may also result from the winter elevation of air probes at some sites. This was necessary, however, to collect winter records of any length at higher elevations, given deep snowpack and infrequent visits to the sites.

Acknowledgements:

We thank R. H. Waring and R. L. Fredriksen for the use of their thermographs, and J. F. Franklin for his aid throughout the project. Many other persons contributed to the collection and reduction of the data, and their efforts are appreciated.

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APPENDIX A

Monthly average temperatures (°F) for reference stands. "m" indicates that 1 to 5 days data are missing for that average. Data for months with more than five missing days are not represented.

			AIR TEMPERATURES							SOIL TEMPERATURES		
Ref. Stand	Year	Month	Mean Day	Mean Night	Mean Max.	Mean Min.	Max	Min	Mean Range	Mean	Max	Min
1	70	May	56.8	49.7	66.4	42.5	88	34	23.8	51.8	59	46
		Jun	63.0m	55.6m	71.5m	51.2m	96m	43m	20.3m	60.2m	65m	56m
		Jul	–	–	–	–	–	–	–	–	–	–
		Aug	69.5	60.3	82.7	50.6	98	45	32.1	64.1	65	63
	71	Apr	41.8m	38.2m	52.0m	32.5m	73m	28m	19.6m	46.3m	48m	43m
		May	52.6	45.9	61.2	40.4	88	33	20.9	50.1	55	46
		Jun	57.8	52.0	66.8	45.7	87	37	21.1	53.7	58	49
		Jul	68.7	64.0	80.3	54.6	95	45	25.7	60.0	64	55
		Aug	71.9	61.4	82.8	55.1	104	46	27.7	62.3	65	60
		Sept	61.4	52.3	71.0	46.7	88	39	24.3	57.1	60	51
		Oct	50.2	44.9	57.7	39.1	84	24	18.6	52.0	59	44
		Nov	41.3	38.6	46.3	34.2	56	28	12.2	44.2	46	41
		Dec	34.0	32.4m	36.4	30.3m	45	21m	6.2	38.6	42	37
	72	Jan	33.9	31.7	37.2	27.9	46	16	9.3	37.6	42	36
		Feb	39.6	35.8	44.3	32.2	54	16	12.1	39.5	43	36
		Mar	43.2	40.2	50.5	34.8	72	29	15.7	43.1	49	38
		Apr	43.2	37.7	50.4	33.0	74	29	17.4	42.9	47	41
		May	59.3	48.8	67.4	43.8	92	36	23.6	49.5	58	45
		Jun	63.3	54.4	72.7	49.1	92	40	23.6	57.4	60	54
		Jul	72.8	61.3	83.9	54.6	100	45	29.3	62.4	65	58
		Aug	71.5	62.4m	85.0	54.3m	109	47m	30.7	62.5	68	59
		Sep	60.7	52.4	70.6	46.2	97	34	24.5	57.4	62	53
		Oct	50.8	48.2	61.4	41.0	81	30	20.4	54.1	57	47
		Nov	43.9	42.9	48.3	38.7	55	32	9.6	48.6	50	47
		Dec	32.1	31.2	36.8	26.4	51	1	10.4	41.8	47	40

Ref. Stand	Year	Month	AIR TEMPERATURES Mean Day	Mean Night	Mean Max.	Mean Min.	Max	Min	Mean Range	SOIL TEMPERATURES Mean	Max	Min
2	70	Jul	66.3	60.7	79.1	49.3	93	42	29.8	57.0	58	54
		Aug	66.9	56.9	79.9	46.9	94	42	33.0	57.3	58	56
	71	Apr	42.0m	36.9m	49.3m	31.5m	68m	27m	17.9m	40.2m	40m	37m
		May	51.6	43.6	58.3	39.3	81	32	19.0	45.7	49	42
		Jun	56.9	50.4	64.9	44.0	84	39	20.9	49.1	52	46
		Jul	70.6	58.3	80.0	53.3	95	44	26.7	54.6	59	51
		Aug	70.2	58.8	80.2	52.4	100	43	27.9	58.6	60	57
		Sept	56.2	51.0	65.4	43.6	78	38	21.8	54.6	57	51
		Oct	46.7	42.9	52.9	36.6	74	23	16.3	48.3	52	42
		Nov	39.8	37.7	43.5	33.3	51	26	10.2	41.2	42	39
		Dec	33.5	32.2m	34.8	30.6m	44	20m	4.2	34.7	39	33
	72	Jan	32.8	31.0m	35.2	27.7m	44	17m	7.5	33.5	37	32
		Feb	37.8	35.0	41.6	31.6	52	15	10.0	35.5	38	34
		Mar	42.1	39.9	48.1	34.5	67	30	13.6	37.9	41	33
		Apr	42.2	38.7	48.7	33.3	72	28	15.4	39.2	41	38
		May	57.2	49.2	66.0	42.0	91	34	24.0	46.9	53	39
		Jun	62.3	55.0	71.8	47.9	85	41	23.9	53.6	55	52
		Jul	69.6	60.2	81.4	51.8	94	43	29.6	57.7	60	55
		Aug	70.7	58.1	81.4	51.7	104	45	29.7	60.6	64	59
		Sept	58.5	49.8	66.4	43.8	92	32	22.6	56.2	61	51
		Oct	49.5	43.6	56.5	37.7	73	27	18.8	50.2	53	45
		Nov	41.2	40.7	44.6	36.7	51	30	7.9	44.4	45	43
		Dec	28.2m	28.7m	31.9m	23.3m	49m	-4m	8.6m	39.3m	45m	36m
3	70	May	47.2m	43.0m	54.4m	37.8m	79m	27m	16.6m	40.2m	36m	34m
		Jun	-	-	-	-	-	-	-	-	-	-
		Jul	63.2	58.9	73.5	51.4	89	43.0	22.1	54.2	56	50
		Aug	63.8	56.8	73.5	50.1	87	44	23.4	54.6	56	53
	71	Jun	52.8	47.5	60.1	43.3	79	34	16.8	44.8	49	40
		Jul	65.6	58.9	75.0	53.5	88	43	21.6	51.7	56	47

			AIR TEMPERATURES							SOIL TEMPERATURES		
Ref. Stand	Year	Month	Mean Day	Mean Night	Mean Max.	Mean Min.	Max	Min	Mean Range	Mean	Max	Min
3	71	Aug	65.1	59.3	73.6	53.7	94	42	19.9	55.6	58	54
		Sept	51.8	49.0	57.3	44.1	69	32	13.2	49.8	51	42
		Oct	42.7	41.4	46.9	36.7	72	19	10.2	43.8	49	38
		Nov	35.1	34.2	37.8	31.3	48	25	6.5	36.3	39	33
		Dec	29.1	28.2m	30.7	26.0m	40	18m	4.7	32.6	33	32
	72	Jan	28.9	27.6	30.6	24.8	41	10	5.8	32.0	33	31
		Feb	34.0	33.1	36.4	30.2	48	16	6.2	31.7	32	31
		Mar	37.2	35.5	40.4	31.8	53	23	8.6	31.8	32	31
		Apr	34.8	32.6	39.0	28.5	58	21	10.5	33.7	33	32
		May	51.9	44.9	58.9	40.3	87	31	18.6	40.9	50	33
		Jun	56.6	51.4	65.2	46.2	82	34	19.0	50.0	52	48
		Jul	67.4	61.8	77.3	55.8	91	42	21.5	56.1	59	53
		Aug	68.0	61.0	76.2	55.9	100	45	20.3	56.3	60	52
		Sept	54.5	49.9	60.2	45.0	86	33	15.1	51.5	57	46
		Oct	47.5	44.8	51.6	40.9	69	26	10.7	48.2	50	43
		Nov	39.8	39.3	42.0	36.3	47	30	5.7	41.9	43	39
		Dec	28.9	28.1	31.0	24.0	47	-.3	7.0	37.7	41	34
4	70	Jul	61.8	57.0	69.6	51.5	85	42	18.1	52.3	55	47
		Aug	62.9	55.6	70.7	51.1	82	43	19.6	52.4	54	50
		Sept	48.7	45.5	53.2	40.9	64	31	12.3	47.2	51	45
	71	Jul	62.5	56.8	70.1	52.4	84	39	17.7	50.3	57	44
		Aug	63.4	57.5	70.5	52.4	91	41	17.4	54.7	58	51
		Sept	48.3	44.7	52.6	40.3	66	29	12.3	47.3	50	39
		Oct	40.8	38.2	43.8	34.8	68	16	8.9	41.9	50	37
		Nov	34.1	33.0	36.1	29.6	51	22	6.6	35.3	37	34
		Dec	26.1	25.8m	27.8	22.8m	37	15m	5.0	33.2	34	33
	72	Mar	35.2	33.7	38.0	29.9	55	19	8.1	32.5	33	32
		Apr	-	-	-	-	-	-	-	-	-	-
		May	-	-	-	-	-	-	-	-	-	-

			AIR TEMPERATURES							SOIL TEMPERATURES		
Ref. Stand	Year	Month	Mean Day	Mean Night	Mean Max.	Mean Min.	Max	Min	Mean Range	Mean	Max	Min
6	71	Sept	57.4	51.5	66.5	45.4	83	37	21.2	55.7	57	52
		Oct	48.0	43.5m	55.1	37.4m	80	21m	17.7	50.9	57	44
		Nov	39.9	37.2	45.0	33.1	54	26	11.9	43.3	46	40
		Dec	32.6	31.4	34.9	29.0	43	19	5.9	36.8	41	35
	72	Feb	40.0	35.8	44.0	32.5	56	16	11.5	37.2	40	34
		Mar	41.8	40.0	48.9	34.1	70	27	14.8	40.3	45	35
		Apr	41.8	36.1	48.1	32.0	74	27	16.1	40.1	43	38
		May	57.6	47.4	66.2	42.4	83	34	23.8	46.7	52	40
		Jun	61.6	56.8	72.3	48.8	85	41	23.5	53.2	55	51
		Jul	70.4	64.7	82.6	55.0	95	45	27.6	59.1	63	55
		Aug	71.6	59.9	81.9	54.3	104	45	27.6	61.3	65	58
		Sept	59.4	51.7	68.2	45.7	93	32	22.5	57.2	62	53
		Oct	52.7	46.4	60.4	41.3	80	29	19.1	53.2	56	47
		Nov	43.3	40.9	47.1	37.4	54	32	9.7	47.9	49	46
		Dec	32.7	30.5	36.0	26.2	54	-1	9.8	39.5	46	38
7	71	Jun	57.2	51.2	64.7	45.0	83	40	19.8	50.5	54	47
		Jul	66.5	61.8	77.8	52.2	91	42	25.5	55.5	60	51
		Aug	69.4m	62.5m	80.6m	53.8m	99m	42m	26.8m	59.8m	62m	58m
		Sept	55.0	49.5	62.2	42.6	75	37	19.7	53.5	56	48
		Oct	45.1	42.5	50.8	35.9	70	22	14.9	48.6	53	42
		Nov	39.0	36.9m	42.5	32.7m	49	26m	9.8	41.7	44	40
		Dec	32.2	31.7m	33.7	29.6m	40	20m	4.1	36.2	41	35
	72	Jan	31.8	30.4	33.9	27.0	42	16	6.9	34.7	38	33
		Feb	37.5	34.9	40.7	31.5	51	15	9.2	36.7	40	34
		Mar	42.3	40.4	47.4	35.1	63	30	12.3	40.2	44	36
		Apr	41.9	37.7	47.3	32.7	69	27	14.6	40.6	44	38
		May	55.8	48.2	64.0	41.1	87	33	22.9	47.6	53	41
		Jun	60.1	54.2	69.5	46.7	84	40	22.8	53.5	56	52
		Jul	69.3	58.2	79.8	50.8	93	42	29.0	57.5	60	55
		Aug	69.6	59.5	80.3	51.8	102	46	28.5	58.6	62	55

Ref. Stand	Year	Month	AIR TEMPERATURES Mean Day	Mean Night	Mean Max.	Mean Min.	Max	Min	Mean Range	SOIL TEMPERATURES Mean	Max	Min
4	72	Aug	63.5	56.8	69.3	53.4	93	40	15.9	54.7	60	51
		Sept	49.9	47.6	54.8	42.3	79	28	12.5	48.3	55	40
		Oct	44.7	41.4m	47.8	38.0m	64	24m	9.8	44.6	48	39
		Nov	35.2	34.9	37.4	31.8	44	26	5.6	38.6	41	37
5	71	Jun	51.2	47.4	57.7	42.4	77	32	15.3	46.5	50	42
		Jul	65.0	59.4	73.1	54.0	86	44	19.1	53.1	58	49
		Aug	64.6	59.5	72.7	53.5	92	43	19.2	57.6	61	55
		Sept	53.4	48.4	57.9	43.9	70	31	13.9	52.2	54	45
		Oct	44.4	41.6	48.3	37.1	73	21	11.1	46.6	53	39
		Nov	35.9	35.5	39.3	32.0	50	25	7.3	39.5	42	36
		Dec	28.9	29.2m	31.0	26.3m	41	21m	4.7	34.9	36	34
	72	Jan	29.9m	28.9m	32.2m	26.1m	41m	10m	6.1m	33.9m	35m	33m
		Feb	-	-	-	-	-	-	-	-	-	-
		Mar	38.0	37.0	42.0	32.2	57	22	9.8	35.9	40	33
		Apr	36.5	33.7	41.7	29.1	66	23	12.6	36.2	40	34
		May	51.2m	46.3m	57.7m	40.4m	84m	29m	17.3m	43.1m	51m	39m
		Jun	55.2	50.5	62.4	45.5	77	34	16.9	50.1	52	48
		Jul	64.1	60.5	72.8	53.7	86	41	19.1	54.6	57	52
		Aug	67.1	61.3	74.5	55.9	96	46	18.6	57.6	61	54
		Sept	55.2	50.8	60.7	45.9	85	35	14.8	53.8	59	48
		Oct	48.4	45.8	52.7	41.8	69	33	10.9	49.7	52	43
		Nov	40.1	40.2	42.9	36.8	50	30	6.1	42.9	46	42
6	*70	Jun	62.6	55.3	74.6	49.3	105	38	25.3	51.9	56	48
		Jul	70.0	59.4	86.3	52.0	104	44	34.3	58.2	62	54
		Aug	70.0	59.2	87.9	50.8	107	46	37.1	60.1	61	59
	71	May	52.7	44.8	60.3	39.4	82	33	19.6	45.9	49	43
		Jun	57.6	48.1	64.8	44.9	85	39	19.9	50.2	54	47
		Jul	71.3	60.1	81.2	54.8	97	43	26.4	57.0	62	49
		Aug	70.6	58.7	80.1	53.7	99	42	26.5	61.2	63	60

Ref. Stand	Year	Month	AIR TEMPERATURES Mean Day	Mean Night	Mean Max.	Mean Min.	Max	Min	Mean Range	SOIL TEMPERATURES Mean	Max	Min
7	72	Sept	56.8	50.2	64.2	43.5	88	33	20.4	54.6	59	50
		Oct	47.9	44.1	54.3	37.6	70	28	16.7	50.6	53	44
		Nov	42.2	42.2	45.9	38.0	54	31	7.9	45.9	48	44
8	71	May	51.7	47.0	60.2	40.7	84	33	19.5	48.1	51	44
		Jun	55.3	51.1	64.9	45.2	85	38	19.8	51.2	57	46
		Jul	70.1	61.0	79.9	54.4	93	44	25.5	59.3	65	55
		Aug	70.5	61.3	80.8	54.5	101	44	26.3	61.7	66	58
		Sept	58.3	51.6	66.9	45.5	84	38	21.4	55.4	59	48
		Oct	48.2	43.9	54.8	38.0	80	23	16.8	49.7	57	41
		Nov	39.5	38.1	44.9	34.1	53	28	10.8	43.0	45	41
		Dec	33.3	31.5m	35.5	30.5m	45	22m	4.9	37.0	42	36
	72	Jan	34.4	32.5	37.2	28.8	47	16	8.4	36.7	43	34
		Feb	39.7	36.2	43.7	33.0	53	16	10.7	38.8	42	34
		Mar	44.5	40.2	50.2	36.0	70	30	14.2	42.1	48	35
		Apr	42.7	37.8	49.4	31.9	73	29	16.5	42.0	47	38
		May	56.9	50.0	65.8	42.8	91	34	23.0	50.6	58	43
		Jun	62.1	55.1	71.5	48.9	87	41	22.6	56.9	60	53
		Jul	71.4	63.8	82.8	54.9	95	46	27.9	61.5	65	57
		Aug	70.0	62.7	82.0	54.1	104	46	27.9	62.3	67	57
		Sept	58.9	53.6	68.4	46.3	93	34	22.1	56.4	63	50
		Oct	50.5	47.4	58.9	41.0	79	30	17.9	51.5	55	44
		Nov	43.3	42.2	46.0	37.3	54	32	8.7	46.7	48	45
		Dec	32.7	31.2	35.3	27.2	52	0	8.1	40.2	46	36
9	71	May	52.2	45.2	60.1	40.3	81	32	19.8	46.9m	51m	42m
		Jun	56.3	49.7	64.7	44.1	84	39	20.6	52.2	56	49
		Jul	69.7	58.6	79.9	53.2	94	43	26.7	56.9	62	53
		Aug	69.7	60.9	80.7	53.9	99	47	26.9	60.5	63	57
		Sept	57.9	51.4	65.7	45.2	79	38	20.5	53.8	56	49
		Oct	46.8	43.3	52.6	37.4	74	21	15.2	48.6	52	41

			AIR TEMPERATURES							SOIL TEMPERATURES		
Ref. Stand	Year	Month	Mean Day	Mean Night	Mean Max.	Mean Min.	Max	Min	Mean Range	Mean	Max	Min
9	71	Nov	39.4	36.7	42.8	32.6	50	26	10.2	41.9	43	40
		Dec	32.0	31.8m	33.6	29.7m	40	19m	3.8	36.4	40	36
	72	Jan	31.8	30.7	34.2	27.0	43	16	7.2	35.3	36	34
		Feb	37.1	34.4	40.4	31.0	50	14	9.4	36.0	39	34
		Mar	40.0	36.7	45.4	32.3	64	28	13.1	40.2	44	36
		Apr	42.5	38.3	48.6	33.4	74	28	15.2	41.1	44	40
		May	58.6	51.0	67.9	44.0	92	35	23.9	47.5	53	42
		Jun	63.0	55.5	72.9	49.4	87	42	23.5	53.4	55	53
		Jul	71.3	63.1	84.0	54.3	97	46	29.7	57.7	60	55
		Aug	70.9	61.6	82.9	54.1	105	47	28.8	59.2	62	56
		Sept	58.0	52.7	67.2	45.3	91	33	21.9	54.8	60	49
		Oct	49.8	45.4	56.9	39.0	72	29	17.9	49.9	52	44
		Nov	41.8	40.5	44.8	36.7	53	31	8.1	45.3	46	44
		Dec	29.9	28.8	33.1	24.5	48	-4	8.6	39.1	44	35
10	71	May	50.8	45.2	58.0	39.8	74	32	18.3	44.8	48	41
		Jun	55.2	48.6	63.0	43.4	75	37	19.5	49.4	54	44
		Jul	67.7	58.2	77.2	52.5	92	44	24.7	55.0	60	50
		Aug	67.9	58.9	78.3	52.4	98	42	25.9	58.4	61	56
		Sept	56.4	49.3	63.6	43.9	78	36	19.8	52.8	55	47
		Oct	46.3	41.6	52.4	36.1	79	21	16.3	47.6	54	39
		Nov	37.8	35.1	41.9	31.1	51	25	10.9	40.3	43	38
		Dec	30.8	29.5m	32.6	27.6m	45	18m	5.1	34.3	38	33
	72	Jan	31.2m	28.9m	33.6m	26.3m	43m	13m	7.3m	32.6m	34m	32m
		Feb	36.7	33.4	40.6	30.0	52	14	10.6	34.5	38	32
		Mar	41.4	36.6	47.0	32.3	67	27	14.7	39.0	43	32
		Apr	39.7	34.6	46.6	30.1	70	26	16.5	38.6	42	35
		May	54.7	46.5	63.1	40.0	89	31	23.1	46.6	53	40
		Jun	59.5	53.0	68.9	46.8	85	37	22.1	52.0	55	49
		Jul	70.4	61.0	80.8	54.1	93	46	26.7	57.0	59	54
		Aug	69.8	59.6	80.0	53.3	101	45	26.7	59.8	64	56

Ref. Stand	Year	Month	AIR TEMPERATURES Mean Day	Mean Night	Mean Max.	Mean Min.	Max	Min	Mean Range	SOIL TEMPERATURES Mean	Max	Min
10	72	Sept	56.8	50.8	65.5	44.5	90	33	21.0	54.9	61	49
		Oct	50.7	45.5	57.8	40.2	75	28	17.6	51.0	54	44
		Nov	41.4	40.3	44.8	36.8	52	30	8.0	45.6	48	44
		Dec	30.1	29.1	33.3	24.7	47	1	8.6	39.3	44	36
11	71	Jun	51.2	47.0	58.6	42.2	79	32	16.4	47.1	53	41
		Jul	67.1	59.8	77.2	54.9	92	43	22.2	56.7	65	51
		Aug	68.2	61.9	76.9	56.3	99	45	20.6	61.4	65	58
		Sept	55.3	51.8	61.2	46.5	76	34	14.7	55.2	59	46
		Oct	45.7	43.2	50.1	38.0	76	20	12.1	49.0	57	41
		Nov	37.4	36.1	40.3	32.7	55	26	7.6	39.4	43	35
		Dec	30.0	28.9m	31.7	26.0m	44	20m	5.7	34.3	36	34
	72	Feb	36.4	34.1	39.3	31.2	52	25	8.1	32.5	33	32
		Mar	39.3	36.9	43.3	32.4	63	23	10.9	34.4	38	32
		Apr	37.4	34.2	42.1	29.6	67	23	12.5	35.6	41	34
		May	51.9	49.3	59.7	42.1	87	31	17.6	45.2	53	37
		Jun	56.8	52.4	65.7	47.0	83	35	18.7	52.2	56	49
		Jul	67.2	60.7	77.5	55.2	92	42	22.3	58.1	62	54
		Aug	66.7	62.7	76.6	56.2	102	44	20.4	60.6	65	55
		Sept	56.2	52.8	62.8	46.6	87	33	16.2	56.1	63	48
		Oct	49.2	45.5	53.4	41.4	70	25	12.0	52.1	56	43
		Nov	40.4	39.6	43.2	35.9	51	27	7.3	44.8	46	42
		Dec	30.2	28.3	32.3	25.0	52	-2	7.3	38.8	45	35
12	71	Aug	63.7m	56.4m	72.4m	51.2m	92m	41m	21.2m	55.4m	59m	52m
		Sept	50.1	46.1	56.1	41.7	69	32	14.4	48.7	51	40
		Oct	41.8	39.3	46.0	35.1	66	19	10.9	44.4	51	39
		Nov	34.2	33.5	36.5	30.7	47	23	5.8	36.4	39	33
		Dec	29.3	27.2m	30.4	26.1m	39	19m	4.3	33.0	33	33

			AIR TEMPERATURES							SOIL TEMPERATURES		
Ref. Stand	Year	Month	Mean Day	Mean Night	Mean Max.	Mean Min.	Max	Min	Mean Range	Mean	Max	Min
12	72	Feb	33.4	32.5	35.8	30.1	43	14	5.7	31.8	32	31
		Mar	35.0	33.2	37.9	30.3	49	22	7.6	31.5	32	31
		Apr	34.6	31.8	37.8	29.0	54	22	8.8	31.0	31	31
		May	48.4m	42.5m	57.2m	38.1m	85m	31m	19.1m	37.3m	47m	31m
		Jun	57.6	48.9	65.1	44.0	81	34	21.1	47.6	52	44
		Jul	67.2	57.8	76.5	53.1	90	44	23.4	53.0	56	49
		Aug	65.3	56.5	73.6	52.1	94	43	21.5	54.1	58	50
		Sept	-	-	-	-	-	-	-	-	-	-
		Oct	46.1	43.3	50.5	39.5	64	27	11.0	47.8	50	43
		Nov	37.5	37.3	40.0	34.2	48	26	5.8	41.0	43	38
		Dec	29.3	28.1	30.4	24.8	48	2	6.6	37.2	43	34
13	71	Sept	48.2	44.7	52.8	39.7	69	28	13.1	48.0	53	41
		Oct	41.1	38.4	44.4	34.7	72	15	9.7	41.7	51	36
		Nov	32.5	32.2	35.0	28.2	49	23	6.7	34.6	36	33
		Dec	24.2m	24.6m	26.1m	20.9m	36m	14m	5.2m	32.5m	33m	32m
	72	Apr	30.1	27.5	33.9	23.4	56	18	10.5	32.0	32	32
		May	-	-	-	-	-	-	-	-	-	-
		Jun	50.1	46.5	55.4	42.5	68	29	12.9	41.2	50	33
		Jul	59.1	53.3	65.9	50.1	78	36	15.9	52.3	56	48
		Aug	60.8	55.8	66.3	51.8	90	39	14.5	54.7	61	48
		Sept	48.2	45.0	52.4	40.4	76	29	12.0	49.0	57	40
		Oct	43.6	41.4	47.2	37.0	63	24	10.2	44.2	48	38
		Nov	33.9	33.6	36.2	30.1	46	22	6.1	37.0	39	36
14	71	Sept	48.3	45.1	52.3	39.9	65	28	12.4	43.2	46	36
		Oct	41.3	39.0	44.1	35.1	70	15	9.0	38.2	47	33
		Nov	33.6	32.6	35.6	28.7	50	22	6.9	32.3	33	32
		Dec	24.5	24.0m	26.1	20.7m	39	13m	5.4	32.0	32	32

Ref. Stand	Year	Month	AIR TEMPERATURES Mean Day	Mean Night	Mean Max.	Mean Min.	Max	Min	Mean Range	SOIL TEMPERATURES Mean	Max	Min
14	72	Jan	25.5	25.0	27.1	21.5	41	11	5.6	31.8	32	31
		Feb	–	–	–	–	–	–	–	–	–	–
		Mar	–	–	–	–	–	–	–	–	–	–
		Apr	28.4m	26.4m	32.0m	22.4m	45m	15m	9.6m	30.2m	31m	30m
		May	–	–	–	–	–	–	–	–	–	–
		Jun	50.6	47.0	55.5	43.1	71	29	12.4	32.2	44	30
		Jul	60.9	56.3	66.9	51.5	79	37	15.5	48.3	54	43
		Aug	60.4	56.2	66.0	51.8	89	39	14.2	51.6	59	46
		Sept	49.1	45.9	52.7	41.4	74	30	11.4	45.5	52	38
		Oct	45.1	42.3	47.9	38.2	64	25	9.7	41.9	45	37
		Nov	34.7	34.6	36.9	31.6	46	23	5.3	35.1	36	34
15	*70	May	51.7m	46.8m	58.4m	40.5m	78m	32m	17.9m	45.6m	50m	40m
		Jun	61.9	56.1	68.4	51.1	89	41	17.3	53.5	59	49
		Jul	66.7	61.8	76.3	53.2	89	47	23.1	57.2	59	53
		Aug	64.6	61.2	75.6	51.7	87	47	23.9	56.7	59	55
	72	Jul	68.6	63.7	76.5	56.9	89	46	19.6	60.2	65	54
		Aug	68.1	64.5	76.2	57.7	98	48	18.5	60.8	66	56
		Sept	54.4m	53.0m	60.4m	46.7m	84m	34m	13.7m	–	–	–
		Oct	48.5	46.8	53.0	42.4	67	31	10.6	–	–	–
		Nov	41.7	41.3	43.2	38.3	49	29	5.9	45.9	48	43
		Dec	30.4	29.7m	32.9	26.1m	51	3m	6.8	39.0	44	35
16	72	Jul	69.3	61.5	79.7	54.3	93	44	25.4	59.1	65	54
		Aug	70.2	62.0	80.8	54.8	105	46	26.0	61.1	65	57
		Sept	56.4	52.1	65.1	45.2	90	35	19.9	56.0	63	48
		Oct	49.6	48.5	57.8	41.9	74	31	15.9	53.4	54	45
		Nov	41.3	40.8	44.3	37.3	51	28	7.0	46.3	47	43
		Dec	32.1	30.8m	34.9	27.1m	53	2m	7.8	39.1	45	37

Ref. Stand	Year	Month	AIR TEMPERATURES Mean Day	Mean Night	Mean Max.	Mean Min.	Max	Min	Mean Range	SOIL TEMPERATURES Mean	Max	Min
17	72	Jul	67.8	61.4	81.7	51.0	96	40	30.7	56.5	59	54
		Aug	69.2	58.7	79.1	51.0	99	44	28.1	57.8	62	55
		Sept	55.2	49.3	63.3	42.0	86	30	21.3	53.1	58	49
		Oct	47.0	45.4	55.7	37.3	73	27	18.4	48.7	51	42
		Nov	42.6	41.5	46.3	37.3	54	29	9.0	43.8	45	42
		Dec	29.9	27.9	33.2	24.7	52	-3	8.5	36.3	42	34
18	72	Jul	67.4	59.1	75.1	55.5	88	41	19.6	54.8	59	51
		Aug	67.8	60.1	75.1	55.9	100	42	19.2	57.3	62	53
		Sept	53.6	49.0	58.9	44.0	83	31	14.9	54.3	61	48
		Oct	47.6	44.5	52.2	40.3	71	27	11.9	50.2	53	43
19	72	Jul	67.5	60.4	77.2	54.0	89	45	23.2	58.3	62	56
		Aug	67.7	61.2	76.3	54.5	93	49	21.9	59.6	63	58
		Sept	55.2	51.4	61.4	45.5	84	36	15.9	55.6	60	50
		Oct	–	–	–	–	–	–	–	–	–	–
		Nov	–	–	–	–	–	–	–	–	–	–
		Dec	31.3	30.5m	34.1	26.9m	50	3m	7.2	40.3	45	37
Delta (20)	70	Apr	42.7m	39.4m	49.6m	34.6m	66m	27m	16.1m	43.6m	46	42
		May	54.0	49.3	65.5	39.6	85	33	25.9	49.6	54	43
		Jun	61.8	57.7	74.1	50.6	96	44	24.5	56.9	62	53
		Jul	70.1	60.6	82.7	51.2	97	44	31.5	59.2	61	55
		Aug	68.9	59.1	82.1	48.4	95	43	33.7	58.6	61	57
		Sept	56.6	49.1	64.0	42.6	74	31	21.4	54.5	58	51
		Oct	49.2m	43.9	55.1m	39.0	73	31m	16.5	49.9	54	44
	71	Mar	38.1	34.8	41.9	32.3	55	24	9.9	36.0	40	34
		Apr	46.9	41.5	55.4	35.0	76	30	20.6	42.1	44	40
		May	55.2	49.5	64.2	43.2	87	35	21.0	48.9	51	46

Ref. Stand	Year	Month	AIR TEMPERATURES Mean Day	Mean Night	Mean Max.	Mean Min.	Max	Min	Mean Range	SOIL TEMPERATURES Mean	Max	Min
Delta	71	Jun	58.3	52.7	68.4	46.1	87	41	22.3	52.0	57	47
		Jul	67.8	59.1	78.6	50.8	89	43	27.8	58.1	62	54
		Aug	67.2	59.1	78.2	51.1	96	43	27.2	60.3	64	58
		Sept	54.3	50.1	63.2	42.1	74	36	21.2	54.5	57	51
		Oct	46.0	42.7	52.2	35.7	71	23	16.0	47.7	54	43
		Nov	40.8	37.5	43.4	32.7	49	26	11.0	42.7	44	40
		Dec	33.3	33.0m	35.7	30.4m	43	21m	5.2	36.9	41	34
	72	Jan	33.7	31.5	35.2	28.3	45	17	7.1	36.1	42	34
		Feb	39.6m	36.2m	42.6m	31.7m	52m	19m	11.0m	37.7m	41m	34m
		Mar	43.7	40.7	49.4	34.7	65	29	14.7	40.8	46	32
		Apr	44.2	39.8	51.4	34.1	76	27	17.3	42.5	45	40
		May	59.0	51.9	67.1	43.7	90	35	25.4	50.4	56	43
		Jun	-	-	-	-	-	-	-	-	-	-
		Jul	-	-	-	-	-	-	-	-	-	-
		Aug	69.6	60.7	81.9	51.7	103	45	30.0	60.9	65	57
		Sept	57.9	52.1	66.9	44.1	91	36	22.7	55.8	61	50
		Oct	49.5	45.0	57.1	37.9	70	29	19.2	51.0	53	44
		Nov	43.2	42.0	46.6	38.1	53	32	8.8	46.8	48	45
		Dec	31.9	30.8	34.8	26.5	52	1	8.2	39.6	44	36
Look-out (21)	70	Apr	29.0m	26.9m	32.2m	23.1m	47m	17m	9.1m	34.5m	36m	34m
		May	43.3	39.3	49.1	33.9	74	21	15.2	38.6	46	33
		Jun	54.7	49.6	60.5	43.5	85	30	17.0	49.7	57	44
		Jul	61.3	54.1	67.5	49.8	81	41	17.7	55.4	59	48
		Aug	63.1	54.4	69.3	50.3	85	41	19.0	58.0	60	55
		Sept	49.7	46.6	53.5	40.3	74	27	13.2	48.8	59	44
		Oct	43.1	40.4	46.3	36.4	76	25	9.9	45.1	53	36
		Nov	33.9	32.2	35.7	29.5	57	19	6.2	39.5	43	36
	71	Jun	46.9m	41.7m	52.5m	37.9m	73m	31m	14.7m	44.8m	50m	40m
		Jul	61.2	54.8	67.5	50.8	82	35	16.7	53.1	60	46
		Aug	62.2	54.6	63.9	51.7	92	37	16.3	57.6	62	50

Ref. Stand	Year	Month	AIR TEMPERATURES Mean Day	Mean Night	Mean Max.	Mean Min.	Max	Min	Mean Range	SOIL TEMPERATURES Mean	Max	Min
Look-out	71	Sept	48.7	45.9	52.7	39.9	69	27	12.7	49.1	52	40
		Oct	41.1	38.1	44.2	33.8	72	15	9.8	44.1	53	38
		Nov	33.1	31.3	35.2	29.1	52	21	6.1	35.3	39	34
	72	Jul	65.5	60.8	71.5	54.9	85	41	16.4	54.6	58	50
		Aug	64.9	58.3	71.1	54.8	97	41	16.1	56.6	64	49
		Sept	51.6	46.8	56.6	41.5	83	31	13.9	50.9	59	39
		Oct	44.7	41.1	48.1	37.6	69	23	10.5	46.3	51	38