Temperature-Precipitation Considerations in Eastern Oregon

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TEMPERATURE-PRECIPITATION CONSIDERATIONS IN EASTERN OREGON[1/]

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Only a small part of the base amount of recorded meteorological data has been utilized in attempting to understand how climatic variables influence the biomass production on western rangelands. Simple relations of a few precipitation or temperature statistics with biomass yield have been examined by Rogler and Haas (1947), Smoliak (1956), Burnett and Holdenhauer (1957), Blaisdell (1958), Army et al. (1959), Pingrey and Dortignac (1959), Sneva and Hyder (1962), and Sneva (1977). For the most part, these investigations have considered monthly precipitation amounts and mean monthly temperature. A few of the studies, through multiple regression analyses, have attempted to separate the effects of temperature from the effects of precipitation. Even so, the interpretation of those results is difficult because of the integrated nature of temperature and precipitation. This study was an attempt to understand the relation between temperature and precipitation throughout the year.

The daily temperature record was stratified for days with and days without precipitation for the same calendar date through 21 years. Initially it was hypothesized that temperature would be higher for days without precipitation than for days with precipitation (on the same calendar date) during the summer months but that the relation would reverse during the winter months. As a range scientist my main interest was the time of the crossovers as they might relate to plant activity. Additionally, the variability of the recorded temperature and precipitation values and their derived statistics were examined.

PROCEDURE

Twenty-one years of daily precipitation (PPT) and temperature (TP) records beginning March 1, 1937, and terminating April 30, 1958, for the Squaw Butte Experiment Station provided the raw data for this study. The record was examined for irregularity and missing data were provided by the U.S. Weather Bureau[3/]. The observed data of maximum (MAX) and minimum (MIN) TP and daily PPT along with the computed daily mean (MEAN) and temperature range (TPR) were computer processed and the following data generated:

1. Within each standard climatological week[4/] the weekly mean MAX, MIN, MEAN and TPR for all days, days with and days without PPT and their associated sums of squares and mean squares.
2. Weekly mean MAX, MIN, MEAN, and TPR were ordered by increasing weekly PPT for the 21 years.
3. Within each fourth week, daily mean MAX, MIN, MEAN, and TPR were ordered by increasing daily PPT.
4. A daily mean MAX, MIN, MEAN, and TPR for the 21 years.
5. Mean annual MAX, MIN, MEAN, and TPR for all days, days with and days without PPT.

The manner of computing the standard week means for days with and without precipitation requires further clarification. First, it was assumed that within the standard week there was not a significant trend effect and consequently that each day constituted an independent measurement. Thus, the 7 days of each week for the 21 years provide 147 observations of a single day relation that would be valid for any one of the 7-day positions in each standard week. Secondly, the standard week means derived reflect means calculated from unequal numbers of days with and days without PPT. For example a weekly mean MAX for 1) all days, 2) days with precipitation, and 3) days without precipitation for a single week in one year was determined as follows:

Days	Observed MAX TP	Observed PPT	Max TP for all days	Max TP for days without PPT	Max TP for days with PPT
1	30	0.09	30	----	30
2	32	0.15	32	----	32
3	32	0.06	32	----	32
4	36	0.00	36	36	
5	38	0.00	38	38	
6	40	0.00	40	40	
7	42	0.00	42	42	
Average			35.7	39.0	31.3

The 21 weekly means for each standard week were then averaged to provide the overall estimate of weekly mean. It is observed from the above example that although all-day means are based on 7-day and 21-year estimates, the means for days with and days without PPT might be based on only one day. Indeed for some weeks, particularly during the summer period of low precipitation frequencies, no valid estimate was obtained.

The mean annual statistics for days with and without PPT also were calculated according to the following:

$$\bar{X} = \frac{(X_1 \cdot CC_1) + (X_2 \cdot CC_2) + \cdots (X_{52} \cdot CC_{52})}{CC_1 + CC_2 + \cdots CC_{52}}$$

Where X_1 = mean TP statistic of the week and CC_1 is the card count for that weekly observation.

The standard deviation associated with the above mean was estimated by

$$\frac{\sum SS}{\sum (N-1)}$$

Mean annual MAX, MIN, MEAN, and TPR for all days were estimated from 1) weekly values, 2) annual values, with the variance of the former a pool variance.

Differences between means for days with and without PPT within standard weeks and between successive weeks and measures of the homogeneity of their associated variances were tested as follows:

<u>Testing</u>:	<u>Test Statistics</u>[5/]
Weekly mean differences for days with and without precipitation	$t = \dfrac{\bar{X}_1 - \bar{X}_2}{\sqrt{\dfrac{S_1^2}{N_1} + \dfrac{S_1^2}{N_2}}}$
Homogeneity of weekly variances for days with and without precipitation	$F = \dfrac{S^2}{S^2} \quad (1-x) \ (V_1V_2)$
Weekly mean temperature difference of successive week pairs	95% C.I.
Homogeneity of weekly variances of successive week pairs	$F = \dfrac{S^2}{S^2} \quad (1-x \ (V_1V_2)$
Differences in daily mean temperature within each standard week	Duncan's Range Test
Successive mean day temperature differences within standard week	95% C.I.

RESULTS

Mean weekly MAX, MIN, MEAN TP, and TPR, along with their respective standard deviations, are shown in Figures 1, 2, and 3 of the Appendix. Appendix Figures 4 through 15, inclusive, present the weekly standard deviations for the weekly mean MAX, MIN, MEAN TP and the TPR for: 1) all days, 2) days with PPT, and 3) days without PPT.

Only in the week comprised of the last two days of May and the first five days of June (week 14) did the median weekly PPT exceed 0.3 inch (Figure 1). Weekly median PPT beginning in late October (week 35) through the first of February (week 49) ranged from 0.06 to 0.3 inch with strong differences between successive weeks in some instances. During March, April, and most of May (week 1 to week 12), PPT in successive weeks are generally less than those during winter weeks but with less variation between weeks. A strong weekly increase of PPT is evident for the last two weeks of June (weeks 13 to 16, inclusive) when PPT in these weeks exceeded or equaled that of the winter weeks. The droughtiness of the eastern Oregon summer is vividly displayed in Figure 1. For a period of 15 weeks (weeks 17 to 31) median PPT did not exceed 0.05 inch and in 11 of those weeks the median PPT was zero.

Mean weekly occurrence of days without PPT during the winter months (weeks 35 to 52) ranged from about 60 to slightly less than 80 percent (Figure 2). This frequency of occurrence increased slightly during the spring period (week 1 to 16) but increased sharply during the summer with two-thirds of the weeks experiencing 90 percent or more of the days without PPT. Throughout the entire year there was about a 60 percent or more chance that the days of any week would be without PPT.

Mean MAX TP was significantly ($P < 0.05$) greater for days without PPT than for days with PPT for all weeks beginning near mid-March (week 3) and extending through mid-November (week 38, Figure 3). This relationship crossed over early in December (week 41) and for a period of four weeks (week 42 to 46, inclusive) mean weekly MAX TP was significantly ($P < 0.05$) less for days without PPT than for days with PPT.

Surprisingly, mean weekly MIN TP did not differ significantly ($P > 0.05$) between days without and days with PPT during the spring and most of the summer and early fall (Figure 4). Beginning in late November (week 39), significant differences in the mean MIN TP did occur with some consistency for a period of about nine weeks. During those weeks, mean MIN TP was greater for days with PPT than for days without PPT.

Mean weekly MEAN TP differences for days without and days with PPT were strongly influenced by mean weekly MAX TP and significant relationships between them follow that for MAX TP (Figure 5).

As is common knowledge, the mean weekly TPR was consistently and significantly ($P < 0.05$) lower for days with PPT than for days without PPT for nearly all weeks (Figure 6). Differences were the smallest and most often non-significant during January and February.

Not only did weekly TP differ significantly when separated in such a manner but their variances also differed because of stratification as well as in yearly trend (Appendix Figures 4-15, inclusive). Standard deviations (SD) for mean MAX TP varied considerably more for days with than for days without PPT (Appendix Figures 5 and 6). In the spring months the SD of means tended to increase strongly as the season advanced for days with but not for days without PPT.

Standard deviations associated with mean weekly MIN TP reveal a steady state of fluctuation during spring and summer months with a strong increase beginning in early November (Appendix Figures 7 to 9). This trend occurred for both days with and days without PPT and contrasts sharply with that for the previously discussed SD for MAX TP trends, which were strongly bimodal.

A rather interesting blend of the SD about the MAX (Appendix Tables 5 and 6) with the MIN TP (Appendix Tables 8 and 9) results for the SD about weekly MEAN TP for days with and days without PPT (Appendix Tables 11 and 12). For days with PPT, the strongly increasing trend associated with the SD of the MAX TP dominates in the spring period and the SD of the MIN TP dominate during the fall and winter period. On days with no PPT, the SD associated with MAX TP again strongly influences the forepart of the season causing a decreasing trend in the SD. However, in the winter period, the SD associated with MIN TP exerts major influence and causes the increasing trend in the SD. Low mean TP SD on an all-day basis in the summer period result because of the low SD at this time for MAX TP. The high SD of the mean TP in February is attributed to the large SD associated with MIN TP during this month.

Table 1 presents estimates of annual average TP characteristics for all days, days without PPT and days with PPT and their associated deviations. Average annual MAX TP for days without PPT was 13 degrees higher than that for days with PPT and 3 degrees higher than that for all days; a similar relation is shown for the annual MIN, MEAN TP, and TPR, but the absolute differences were smaller. Standard deviations for all days were estimated in two ways: first, from the weekly means and secondly from pooling of the two data sets. The two procedures estimate different values. From both procedures estimated SD for each TP characteristic was lower from all-days than from stratified data.

The results of testing the variances of the four TP characteristics for days without and days with PPT for their homogeneity within each week are shown in Table 2. In 19 weeks, MAX TP variances between days with and days without PPT differed significantly ($P < 0.05$); for TPR results were similar in 17 weeks. Only in a few weeks did the variances of MIN and MEAN TP differ significantly.

The number of successive week-pairs in which mean TP characteristics differed significantly is presented in Table 3. In no pair of successive weeks for all day comparisons was the mean TP significantly different. The number of successive week-pairs in which mean TP characteristics differed significantly ($P < 0.05$) was greater for days without than for days with PPT. Stratification of the data into days without and days with PPT markedly reduced the number of successive week-pairs for which the variances of mean TP characteristics differed significantly (Table 4).

Individual-day means within each week for the all-days classification were tested with Duncan's range test. As judged by this test, applied at the 0.05 probability level, only in 14 weeks did the range in MEAN TP between days exceed the calculated shortest significant ranges for testing across six units. However, in two of those weeks, the difference was derived from a temperature sequence in reverse order to that normally expected for that season of the year. Maximum difference usually was derived from other days of the week than the first and seventh day.

Successive day means also were tested on data that had been stratified by days without and days with PPT. With this test, however, nearly all differences between mean TP characteristics of successive days were non-significant ($P > 0.05$) and the test abandoned.

The validity of combining the 52 weekly means to estimate an annual mean was tested with Bartlett's test for homogeneity of the variances. For all TP characteristics on an all-days basis, variances of weekly means were all significantly different ($P < 0.01$) as judged by the CHi-square test (Table 5). Stratification of the data into days with and days without PPT significantly reduced these differences, particularly for days without PPT. When the weeks with low frequency of PPT were removed from the days-with-PPT comparison, variance homogeneity was achieved for MEAN TP and TPR characteristics.

The association of weekly PPT with the mean weekly MAX, MIN, TP, and TPR was examined through correlation techniques. Because of low frequency of PPT occurrence during the weeks of 18 to 33, inclusive, no coefficients were generated for those weeks. Weekly PPT and MAX TP were significantly correlated in 12 weeks (Table 6). In all but one week, which was in February, the relationship was negative. Most of the significant relations were in the spring but two were in late October. Most of the positive relations between PPT and MAX TP occurred during December and January.

MIN TP's were significantly correlated with weekly PPT in only three widely scattered weeks; in each of those weeks, the relation was positive. Generally, however, negative associations occurred in the spring and early summer and positive relations in the fall and winter.

In more than half the weeks tested, TPR was significantly and negatively correlated with PPT. Significant relations were found more consistently in the spring than in fall or winter months.

Correlation of daily PPT with daily TP every fourth week was examined with scatter diagrams. Except for a few instances, the scattering of points indicated little if any strong relation between the PPT and TP.

As mean weekly PPT increased, the TP difference between days with and days without PPT significantly increased for all TP characteristics (Table 7). These relations were all significant at the 0.01 probability level and r^2 values ranged from 25 to 36 percent.

In addition, the median weekly PPT also was highly but negatively correlated ($P < 0.01$) with all mean weekly TP characteristics (Table 7). Coefficients were much the same for all four characteristics and approximately 41 percent of the fluctuations were associative with one another.

Neither annual MAX nor MIN TP were significantly correlated with annual PPT. However, the correlation coefficient sign was positive for MIN TP and negative for MAX TP.

DISCUSSION

Separation of the TP data by days with and days without PPT supported the hypothesis that during winter TP on a day was higher than it would have been with PPT on that particular calendar date. Differences for MAX TP between days with and days without PPT were generally greatest during the spring, summer, and fall months but the differences for MIN TP between days with and without PPT were small during the same period. During winter (week 37 through 52), MIN TP was elevated more than MAX TP on days with PPT. Thus the MEAN TP cycle shows that in spring, summer, and fall, precipitation was associated with a depressed TP partly because of lower MAX TP on days with precipitation. However, in winter precipitation was associated with elevated MEAN TP because both MAX and MIN were elevated on days with precipitation.

In this paper the author did not intend to relate the data to plant growth or yield. Findings, however, might be helpful in attempts to clarify the responses of vegetation to climate.

The classification of data into seven-day periods and the assumption that no significant trends are active within weeks are moot. The results of simple statistical tests for TP differences within a week and for successive pairs of weeks uphold that assumption. Thus, to that extent, the assumption within a standard week that daily TP is an independent variable is valid and the data can be treated by standard analysis. Possibly sophosticated statistical tests might reject such as assumption.

Variances about TP statistics reflect a combination of variances that are associated with MAX and the MIN of days with and without PPT. Variances about the MEAN MAX TP were strongly trimodal, and reflect the bimodal variances associated with MAX TP variances for days with and days without PPT. In contrast, variances about MIN TP were monomodal and consistent for all days, days with, and days without precipitation. Thus, consideration of MEAN TP variances for all days shows that days without PPT dominate during the summer and cause low variances and during the winter period the impact of MIN TP which cause high variances. Similarily, the trend in variance for TPR is dominated by that associated with variances derived from days without precipitation.

Dominance of TP and TP variance trends by that associated with days without precipitation should be anticipated for it has been pointed out earlier that such days occurred 60 percent or more of the time. The high variances associated with MIN TP during late winter probably result from the high variable surface cover. Surface conditions during winter range from complete snow cover to bare soil and from a wet surface to a dry surface soil. Incoming radiation can be reflected or absorbed, used to evaporate surface soil water or heat the soil and subsequently the air. Thus, variances are high during winter. The cyclic nature of MAX TP variances is not understood as well; possibly the periods of high variation are associated with main cloud periods. Data usually are stratified to reduce variance; however, with our data variance was greater for stratified than for combined data.

The mean TP statistics are normally used to show the relation between temperature with crop variables. The major exception to this is the computation of heat units in which MAX TP and a particular crop threshold temperature level are used. Results from this study suggest that most sensitive variable was the MAX TP. Fluctuations in the MEAN TP are dampened by adding the MIN TP and taking an average. However, the opportunity to establish long term temperature trends (annual trends) appears to be favored by using MIN TP because they are less influenced by precipitation than MAX TP. However, that advantage might be negated to some extent because variances are greater about annual MIN TP than about either annual MAX TP or MEAN TP.

Correlation of weekly precipitation with TP characteristics corroborates the results found by separating the data into days with and days without PPT. That technique also showed that effects of precipitation also influenced the MAX TP to a greater extent and in more weeks than it did MIN TP. Increases in weekly PPT always depressed the TPR and the depression was significant in 19 weeks.

Literature Cited

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Table 1. Mean annual temperature statistics for all days, days with and days without precipitation

Classification	Temperature Statistic			
	MAX	MIN	MEAN	RANGE
Temperature means				
All days	59	31	46	28
Days without PPT	62	32	47	30
Days with PPT	49	28	39	20
Standard deviations				
All days1/	6.5	5.5	5.5	4.8
All days2/	7.0	6.4	6.2	5.8
Days without PPT	8.6	7.9	7.5	7.0
Days with PPT	8.1	7.7	7.2	6.7

1/ Computed from weekly all day means.

2/ Computer from pooled data of days with and days without PPT.

Table 2. Homogeneity test of variances between days with and days without precipitation[1/]

Week	Temperature variable Max	Min	Mean	Range	Week	Temperature variable Max	Min	Mean	Range
1	n.s	n.s.	n.s.	S	27	n.s.	n.s.	n.s.	S
2	n.s.	n.s.	n.s.	n.s.	28	n.s.	n.s.	n.s.	n.s.
3	S	S	S	S	29	S	n.s.	S	S
4	S	n.s.	n.s.	n.s.	30	S	n.s.	S	S
5	n.s.	n.s.	n.s.	n.s.	31	n.s.	n.s.	n.s.	n.s.
6	n.s.	n.s.	n.s.	S	32	n.s.	n.s.	n.s.	S
7	n.s.	n.s.	n.s.	n.s.	33	n.s.	S	S	n.s.
8	n.s.	n.s.	n.s.	n.s.	34	n.s.	n.s.	n.s.	S
9	S	S	S	S	35	S	n.s.	S	S
10	n.s.	n.s.	n.s.	n.s.	36	n.s.	n.s.	n.s.	S
11	S	n.s.	n.s.	S	37	n.s.	n.s.	n.s.	S
12	n.s.	n.s.	n.s.	n.s.	38	n.s.	S	n.s.	n.s.
13	S	n.s.	n.s.	n.s.	39	n.s.	n.s.	n.s.	n.s.
14	n.s.	n.s.	n.s.	n.s.	40	n.s.	n.s.	n.s.	n.s.
15	n.s.	n.s.	n.s.	n.s.	41	S	S	S	n.s.
16	n.s.	S	S	n.s.	42	S	S	S	n.s.
17	n.s.	n.s.	n.s.	n.s.	43	n.s.	n.s.	n.s.	n.s.
18	S	n.s.	n.s.	S	44	n.s.	n.s.	n.s.	n.s.
19	S	n.s.	S	n.s.	45	n.s.	n.s.	n.s.	n.s.
20	S	n.s.	n.s.	n.s.	46	S	n.s.	n.s.	n.s.
21	n.s.	n.s.	n.s.	n.s.	47	S	n.s.	n.s.	n.s.
22	S	n.s.	n.s.	n.s.	48	n.s.	n.s.	n.s.	n.s.
23	S	n.s.	S	S	49	S	n.s.	n.s.	n.s.
24	n.s.	n.s.	n.s.	n.s.	50	n.s.	n.s.	n.s.	n.s.
25	S	n.s.	S	n.s.	51	n.s.	n.s.	n.s.	n.s.
26	n.s.	n.s.	n.s.	S	52	n.s.	n.s.	n.s.	S

1/ $F = \frac{S^2}{S^2} \left(1-\frac{\alpha}{2}\right) (V_1, V_2)$

n.s. = Non-significant; S = ($P < 0.05$).

Table 3. The number of successive week-pairs in which mean TP differed significantly at the 0.05 probability level

TP characteristic	Week Classification		
	All day	Days WO PPT	Days W PPT
MAX	0	14	6
MIN	0	7	12
MEAN	0	14	9
TPR	0	3	--

Table 4. The number of successive week-pairs in which the variance of mean TP characteristics differed significantly at the 0.05 probability level

TP characteristic	Week Classification		
	All day	Days WO PPT	Days W PPT
MAX	28	17	12
MIN	31	14	8
MEAN	30	2	17
TPR	30	7	7

Table 5. Homogeneity of variance for weekly TP characteristics[1/]

TP characteristic	All days	Days WO PPT	Days W PPT[2/]	Days W PPT[3/]
		Probability level		
MEAN	<0.01	>0.05	<0.01	>0.05
MAX	<0.01	>0.05	<0.01	<0.01
MIN	<0.01	>0.05	<0.01	<0.05
TPR	<0.01	>0.05	<0.01	>0.05

1/ Bartlett's test corrected for unequal numbers.

2/ Week 21 and 24 had insufficient numbers of observations for calculation of a pooled variance.

3/ Data of weeks 17-31, inc. omitted.

Table 6. Weekly correlations of precipitation amount and temperature characteristics

Week No.	Maximum	Minimum	Range
1	-0.361	+0.426*	-0.377
2	-0.149	-0.018	-0.127
3	-0.457	-0.169	-0.483*
4	-0.382	-0.080	-0.365
5	-0.544*	+0.175	-0.755*
6	-0.423	-0.358	-0.308
7	-0.630*	-0.260	-0.637*
8	-0.550*	-0.402	-0.520*
9	-0.541*	-0.296	-0.494*
10	-0.215	+0.259	-0.539*
11	-0.354	-0.256	-0.522*
12	-0.572*	-0.077	-0.665*
13	-0.540*	-0.015	-0.665*
14	-0.583*	-0.058	-0.599*
15	-0.584*	-0.372	-0.616
16	-0.525*	-0.124	-0.561*
17	-0.423	-0.107	-0.620*
.			
.		Insufficient data	
.			
34	-0.459*	-0.048	-0.542*
35	-0.430	+0.210	-0.562*
36	-0.589*	+0.259	-0.718
37	-0.175	+0.054	-0.316
38	-0.303	+0.093	-0.478*
39	-0.048	+0.622*	-0.560*
40	-0.310	-0.053	-0.248
41	+0.104	+0.218	-0.210
42	+0.281	+0.432	-0.423
43	+0.098	+0.248	-0.266
44	+0.144	+0.548	-0.386
45	-0.166	+0.053	-0.508*
46	+0.383	+0.412	-0.221
47	+0.178	-0.264	-0.190
48	-0.131	-0.084	-0.063
49	+0.478*	+0.660*	-0.557
50	-0.103	+0.285	-0.488*
51	-0.423	-0.339	-0.166
52	-0.141	-0.210	-0.191

* = Significant (P = 0.05)

Table 7. Correlation coefficients of TP differences of days with and days without PPT with mean weekly PPT and weekly median PPT correlated with MAX, MIN, MEAN TP, and TPR

	TP characteristics			
PPT	MAX	MIN	MEAN	TPR
Weekly mean	+0.52**	+0.51**	+0.60**	+0.58**
Weekly median	-0.64**	-0.62**	-0.63**	-0.66**

** Significant at ($P < 0.01$).

Figure Titles (text)

1. Median precipitation in inches for standard Weather Bureau week for the Squaw Butte Experiment Station.
2. Frequency of days without precipitation by standard Weather Bureau week for Squaw Butte.
3. Mean daily maximum ambient temperature (F) for days with (X-X) and days without (.-.) precipitation by standard Weather Bureau week for Squaw Butte. Dots denote significant differences at 0.05.
4. Mean daily minimum ambient temperature (F) for days with (X-X) and days without precipitation (.-.) by standard Weather Bureau week for Squaw Butte. Dots denote significant differences at 0.05.
5. Mean daily mean ambient temperature (F) for days with (X-X) and days without (.-.) precipitation by standard Weather Bureau week for Squaw Butte. Dots denote significant differences at 0.05.
6. Mean temperature range (F) for days with (X-X) and days without (.-.) precipitation by standard Weather Bureau week for Squaw Butte. Dots denote significant differences at 0.05.

Footnotes

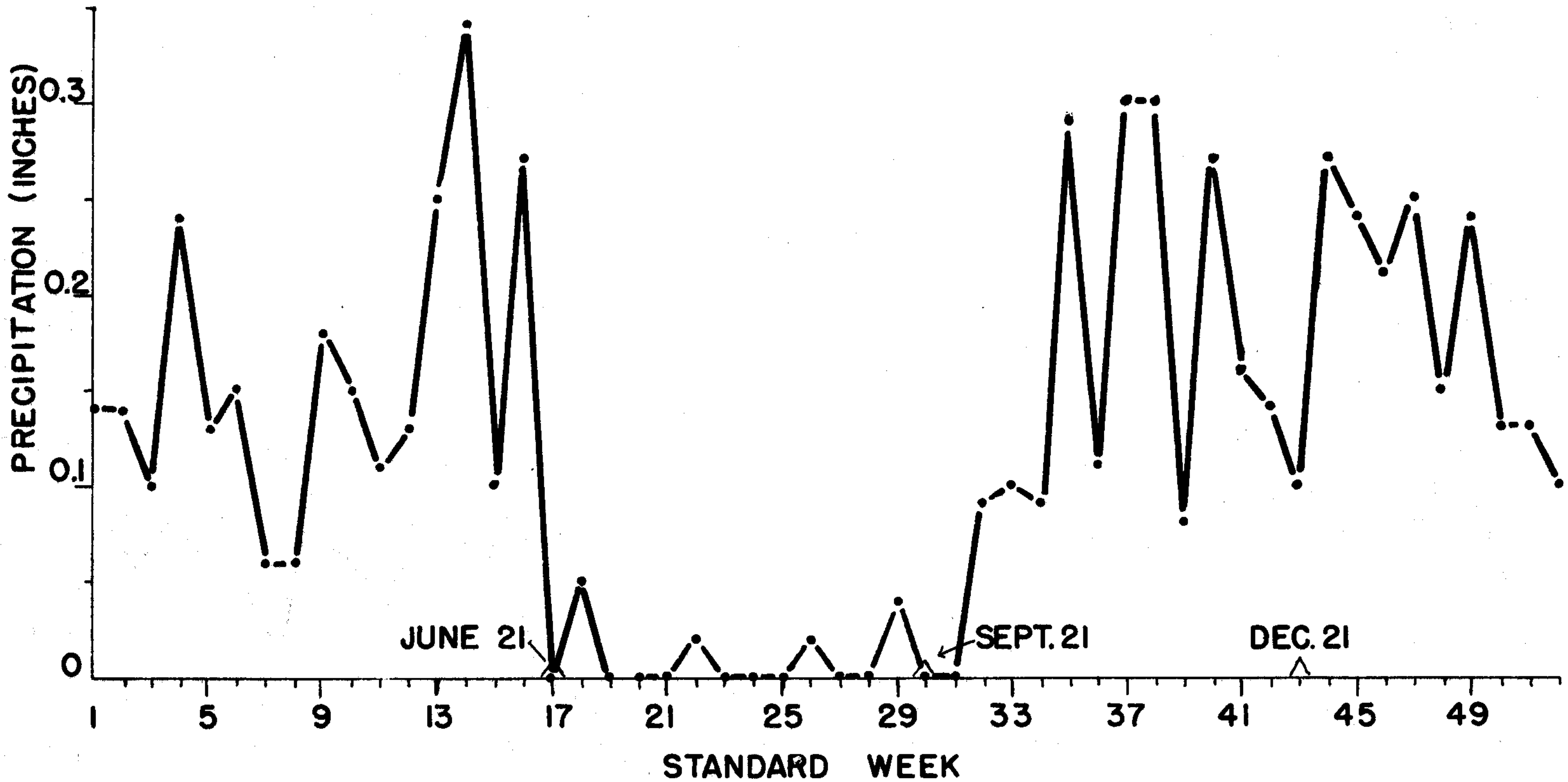
1/ The research is a cooperative investigation of the USDA, Science and Education Administration, Agricultural Research, and the Oregon State Agricultural Experiment Station, Squaw Butte Experiment Station, Burns. Technical Paper No. 4935 of the Oregon State Agricultural Experiment Station.

2/ Range Scientist, USDA, Science and Education Administration, Agricultural Research, Burns, Oregon 97720.

3/ Appreciation is expressed to Mr. G. Sternes, State Climatologist for Oregon, for his assistance and advise.

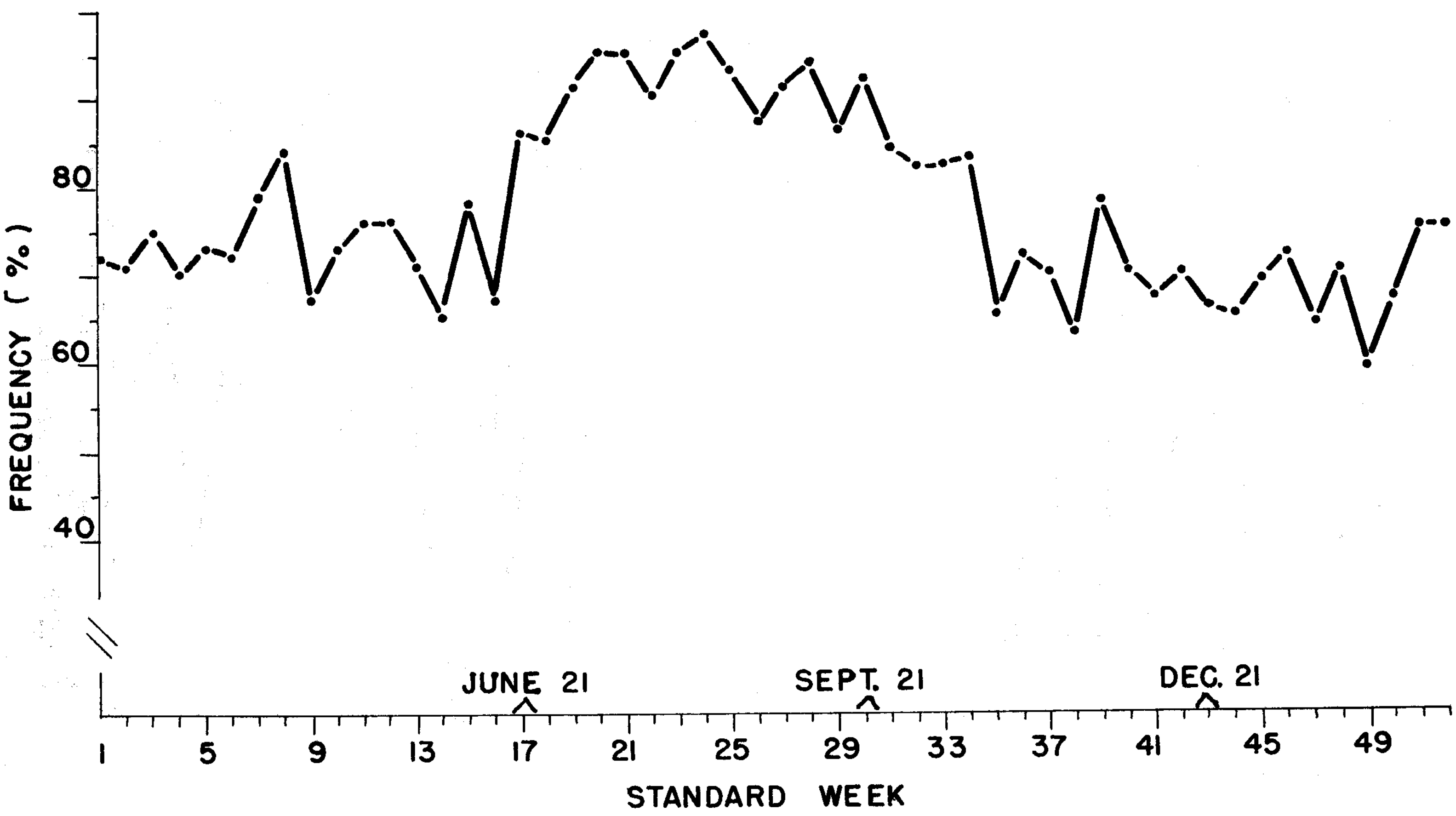
4/ The standard climatological week begins April 1 and lasts 7 days.

5/ Statistical nomenclature follows: Ostle, B. 1964. 2nd Ed. Statistics in Research, Iowa State Univ. Press, Ames.

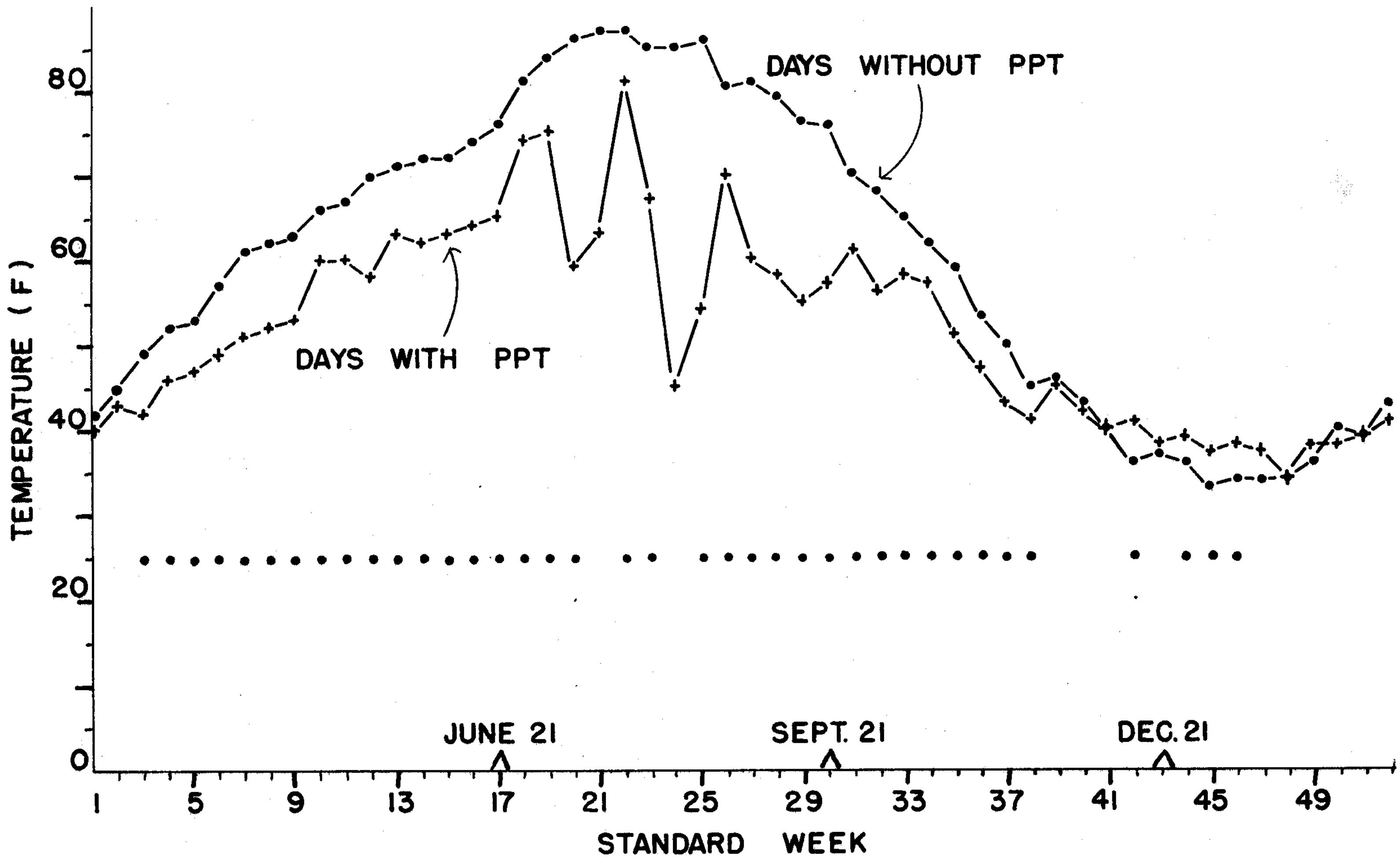


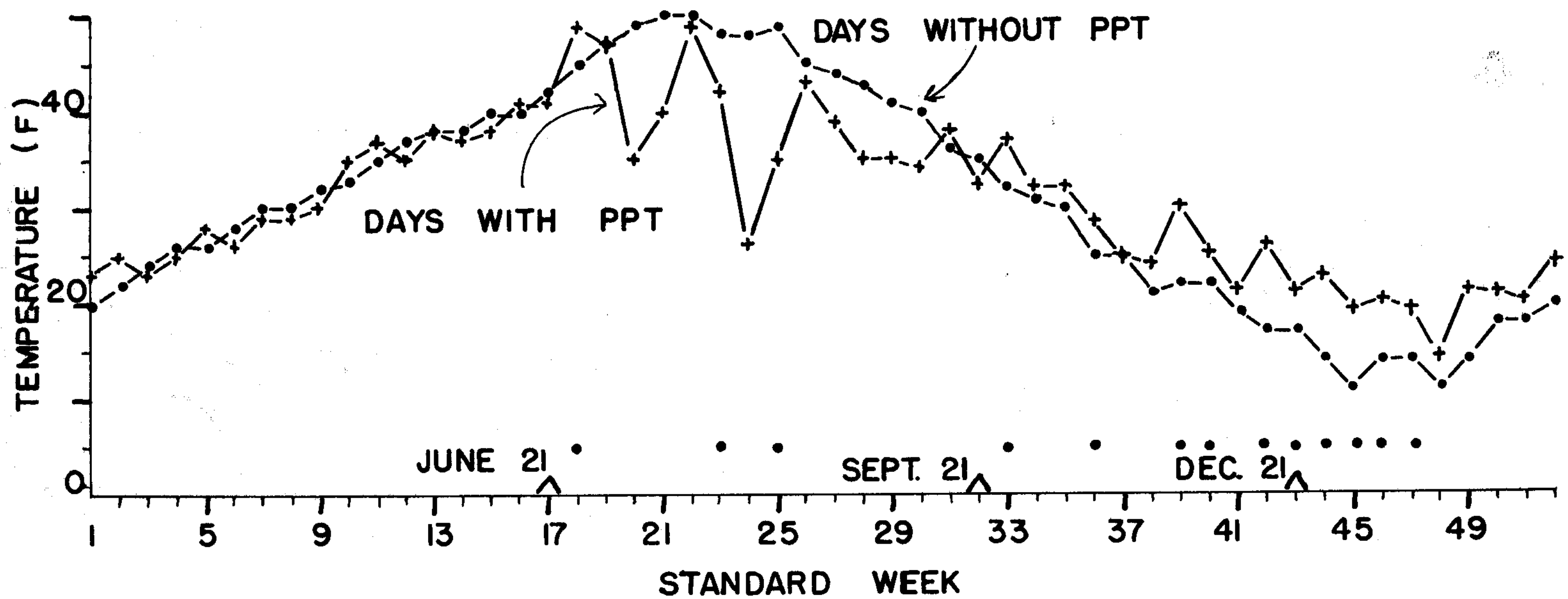
PRECIPITATION (INCHES)
0.3
0.2
0.1
0
JUNE 21
SEPT. 21
DEC. 21
1
5
9
13
17
21
25
29
33
37
41
45
49
STANDARD WEEK

T-1

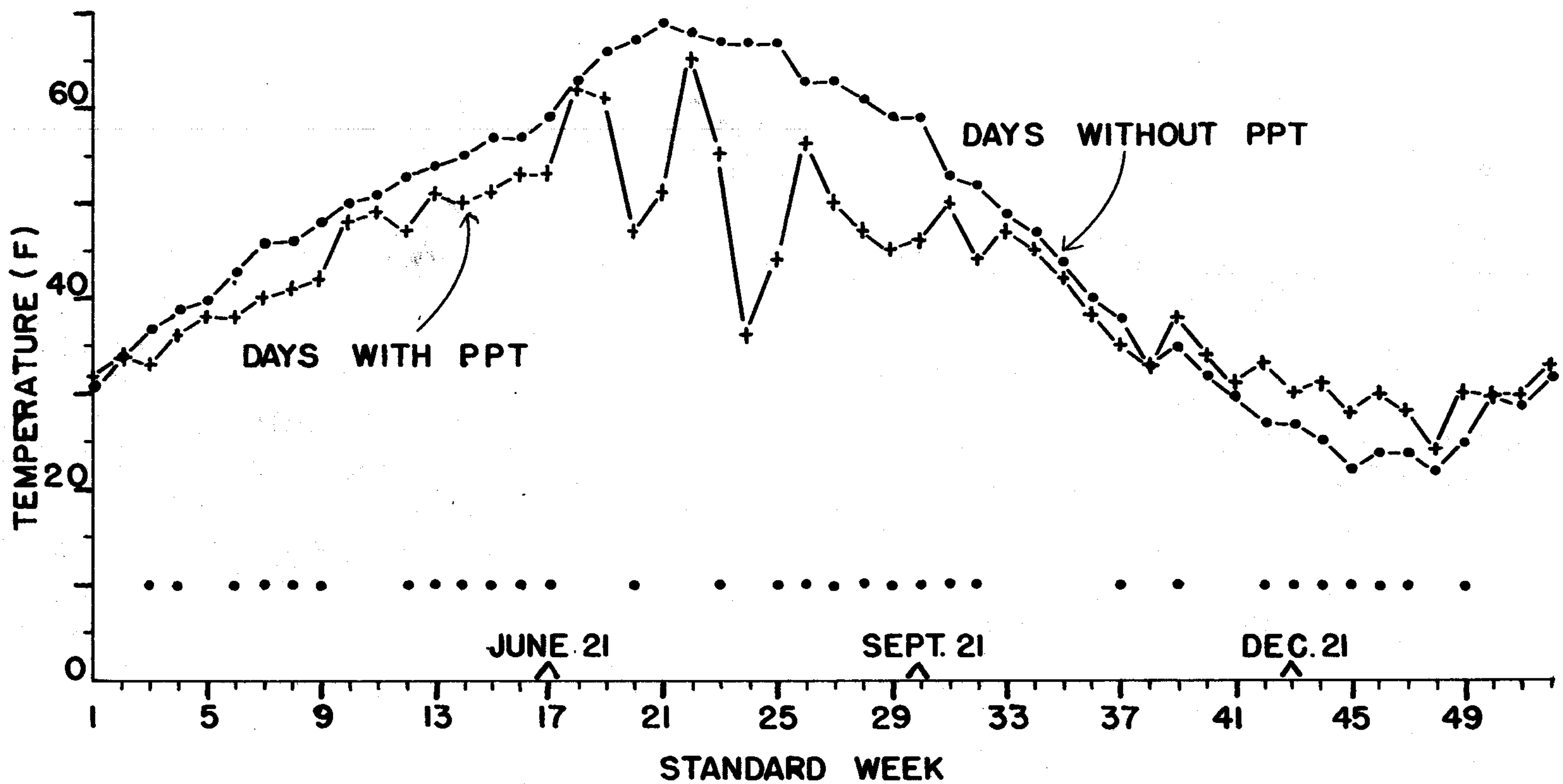

FREQUENCY (%)
80
60
40
JUNE 21
SEPT. 21
DEC. 21
1
5
9
13
17
21
25
29
33
37
41
45
49
STANDARD WEEK

T-2

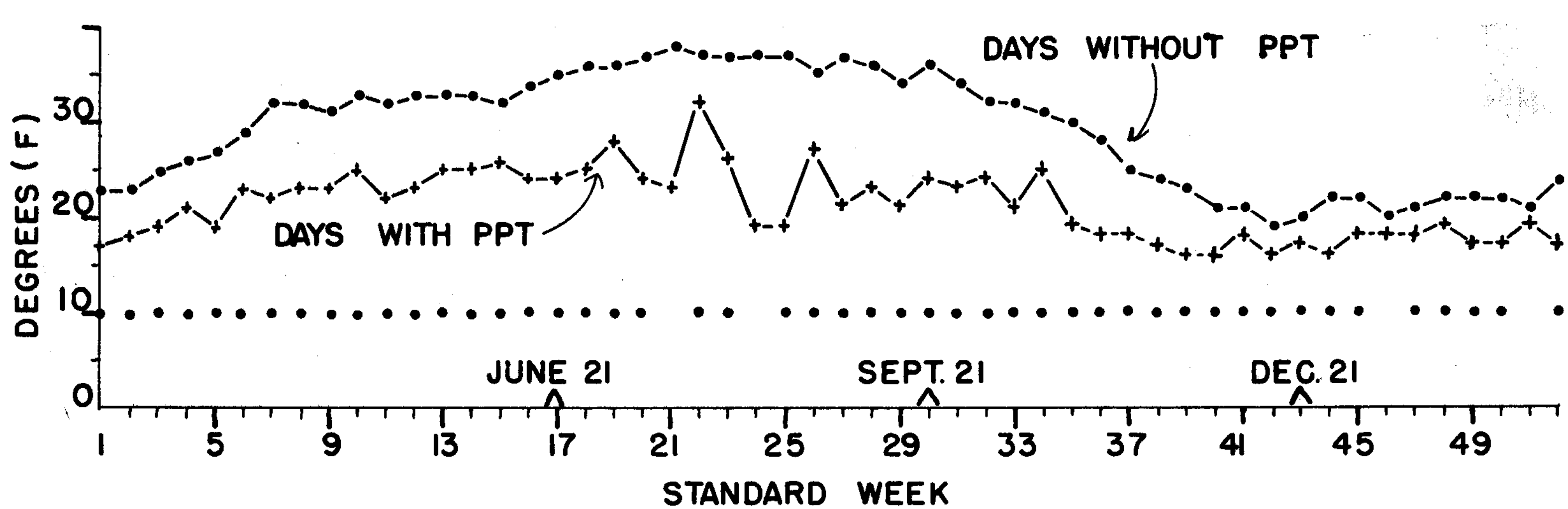

TEMPERATURE (F)
80
60
40
20
0
DAYS WITHOUT PPT
DAYS WITH PPT
JUNE 21
SEPT. 21
DEC. 21
1
5
9
13
17
21
25
29
33
37
41
45
49
STANDARD WEEK



TEMPERATURE (F)
0
20
40
DAYS WITHOUT PPT
DAYS WITH PPT
JUNE 21
SEPT. 21
DEC. 21
1
5
9
13
17
21
25
29
33
37
41
45
49
STANDARD WEEK


TEMPERATURE (F)
60
40
20
0
DAYS WITHOUT PPT
DAYS WITH PPT
JUNE 21
SEPT. 21
DEC. 21
1
5
9
13
17
21
25
29
33
37
41
45
49
STANDARD WEEK

T-5



DAYS WITHOUT PPT
DAYS WITH PPT
DEGREES (F)
30
20
10
0
JUNE 21
SEPT. 21
DEC. 21
1
5
9
13
17
21
25
29
33
37
41
45
49
STANDARD WEEK

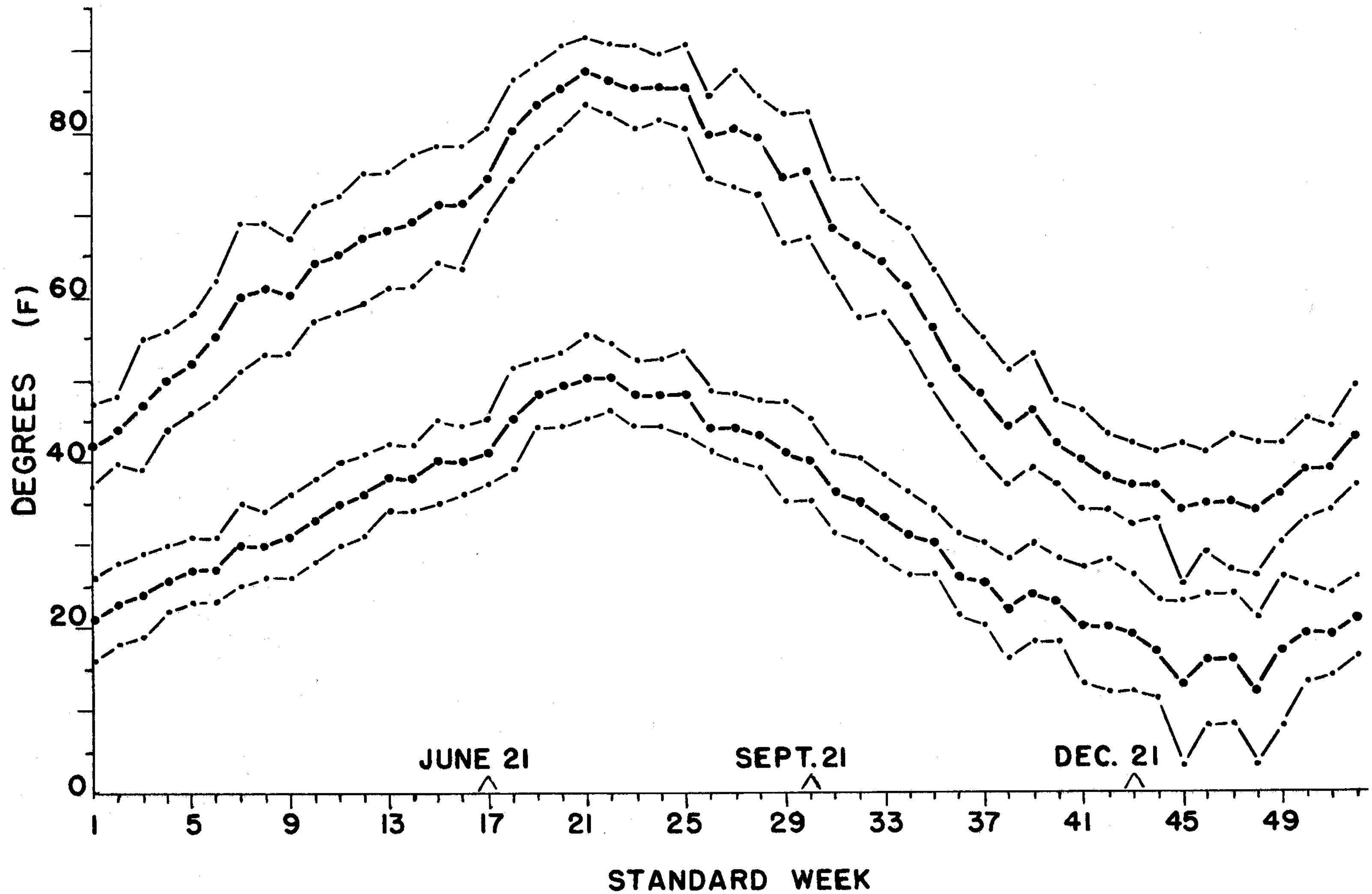
T-6

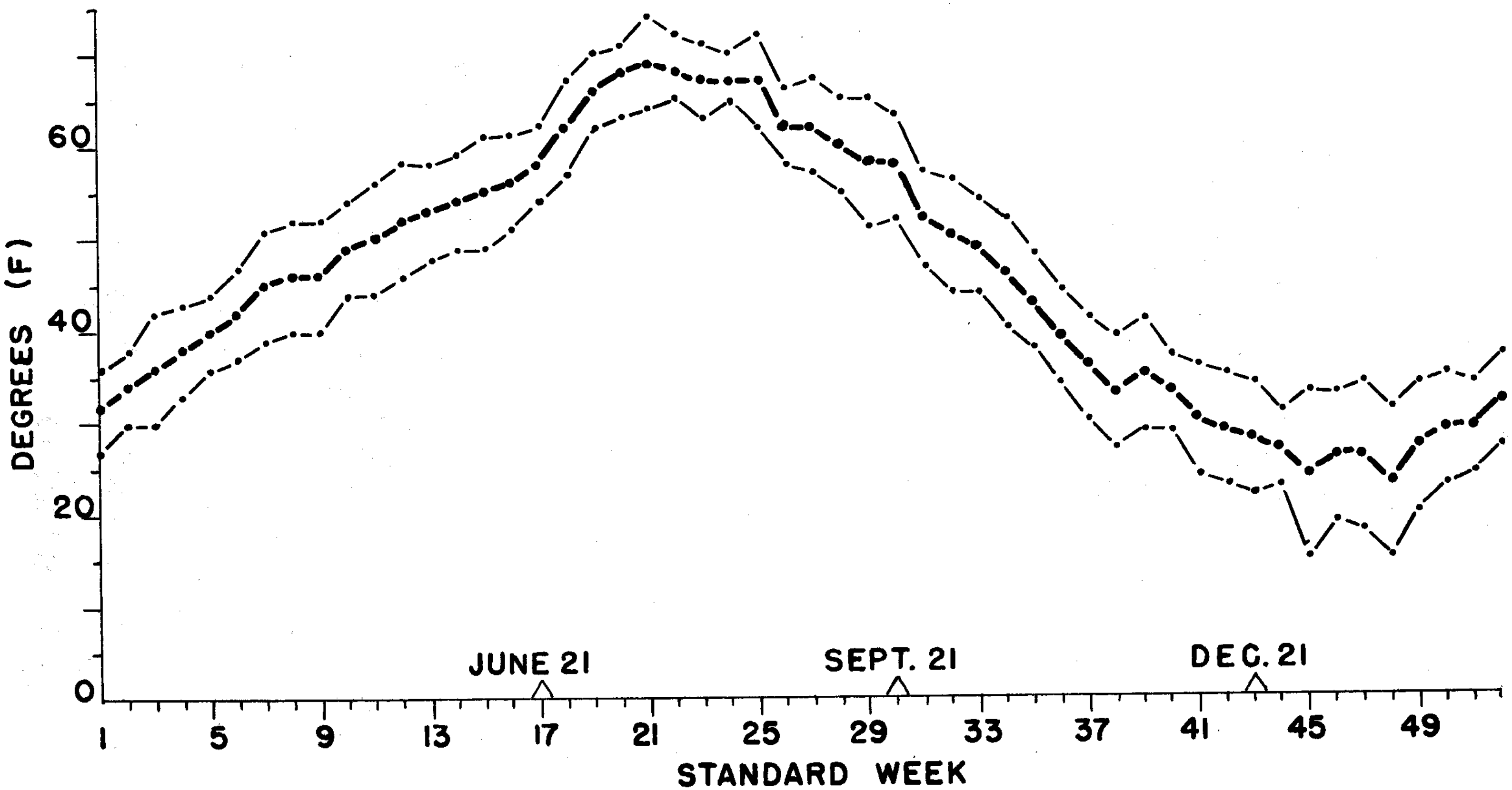
Appendix Figure Titles

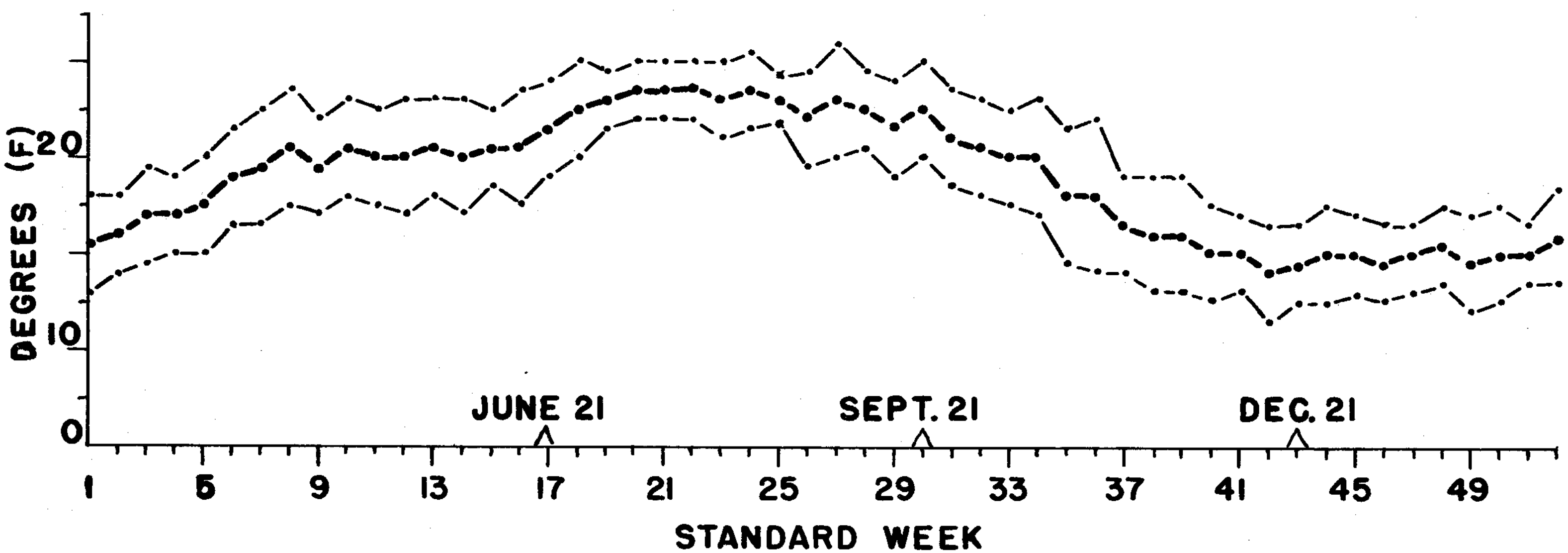
1. Mean daily maximum, minimum temperatures (F) by standard Weather Bureau week and their standard deviations for Squaw Butte.
2. Mean daily mean temperatures (F) by standard Weather Bureau week and their standard deviations for Squaw Butte.
3. Mean daily temperature range (F) by standard Weather Bureau week and their standard deviations for Squaw Butte.
4. Mean maximum temperature standard deviations for all days by standard Weather Bureau week for Squaw Butte.
5. Mean maximum temperature standard deviations for days with precipitation by standard Weather Bureau week for Squaw Butte.
6. Mean maximum temperature standard deviations for days without precipitation by standard Weather Bureau week for Squaw Butte.
7. Mean daily minimum temperature standard deviations for all days by standard Weather Bureau week for Squaw Butte.
8. Mean daily minimum temperature standard deviations for all days with precipitation by standard Weather Bureau week for Squaw Butte.
9. Mean daily minimum temperature standard deviations for all days without precipitation by standard Weather Bureau week for Squaw Butte.
10. Mean daily mean temperature standard deviations for all days by standard Weather Bureau week for Squaw Butte.
11. Mean daily mean temperature standard deviations for all with precipitation by standard Weather Bureau week for Squaw Butte.
12. Mean daily mean temperature standard deviations for all days without precipitation by standard Weather Bureau for Squaw Butte.
13. Mean daily temperature range standard deviations for all days by standard Weather Bureau week for Squaw Butte.

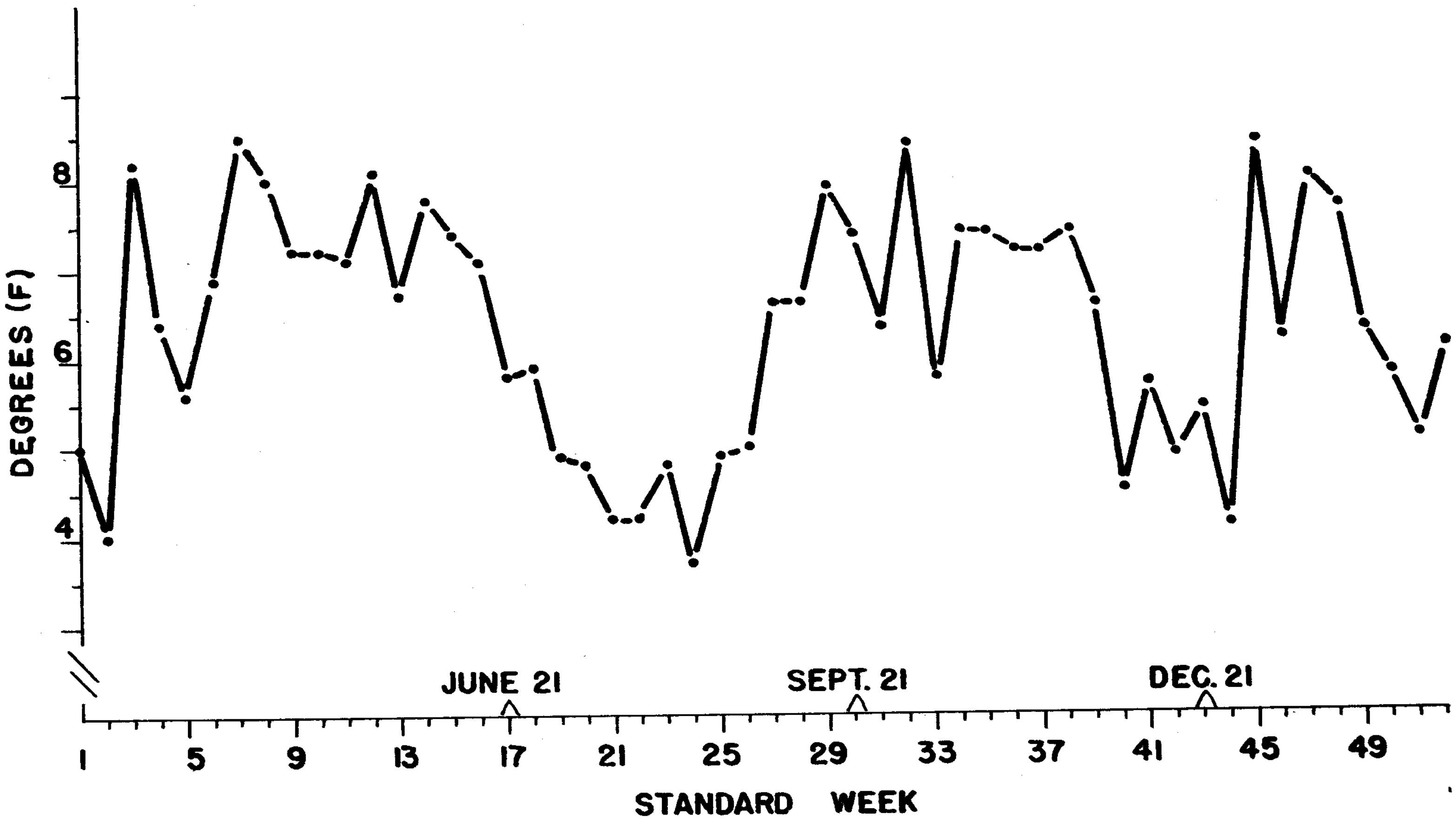
14. Mean daily temperature range standard deviations for all days with precipitation by standard Weather Bureau week for Squaw Butte.

15. Mean daily temperature range standard deviations for all days without precipitation by standard Weather Bureau week for Squaw Butte.

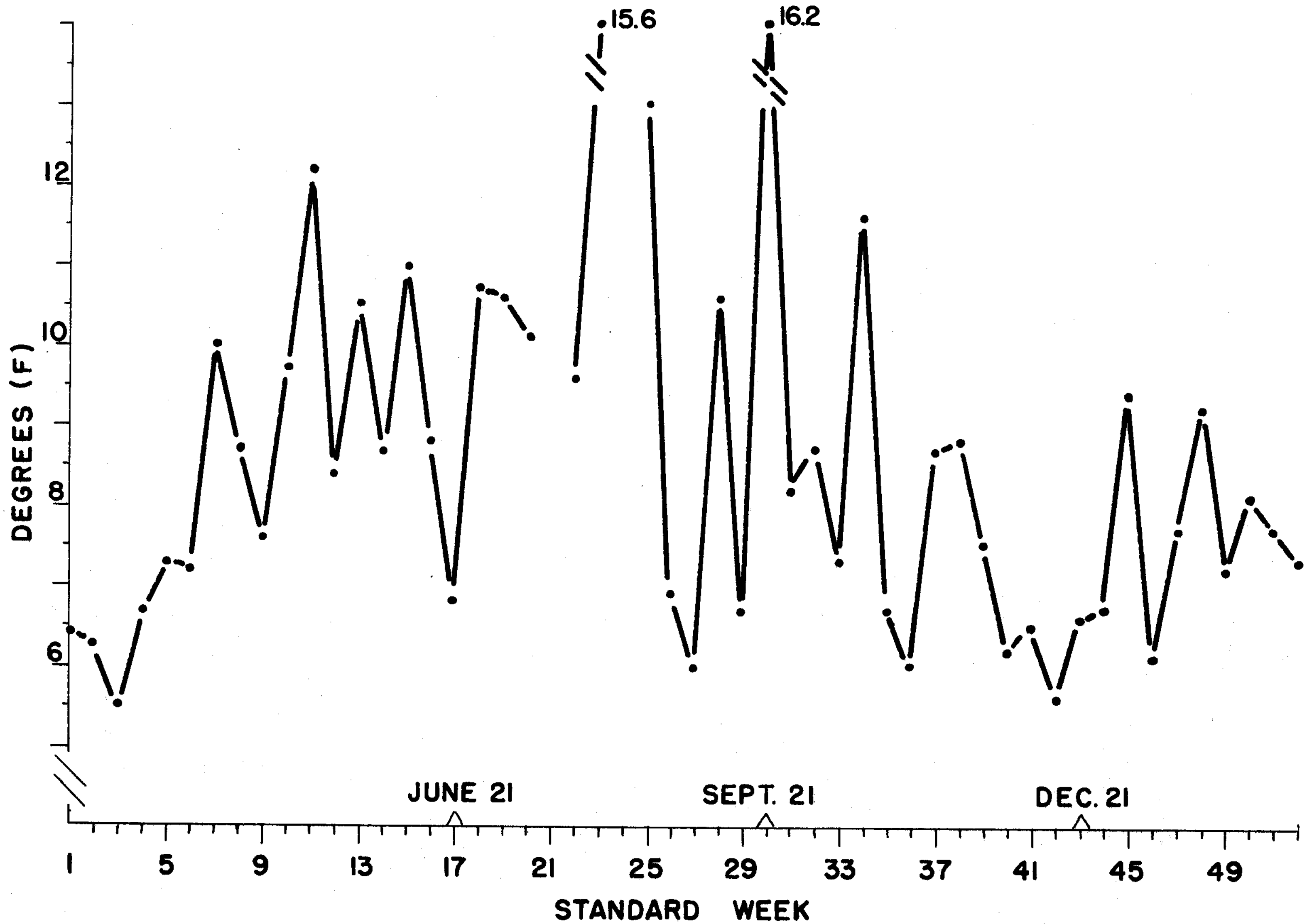

80
60
40
20
0
DEGREES (F)
JUNE 21
SEPT. 21
DEC. 21
1
5
9
13
17
21
25
29
33
37
41
45
49
STANDARD WEEK

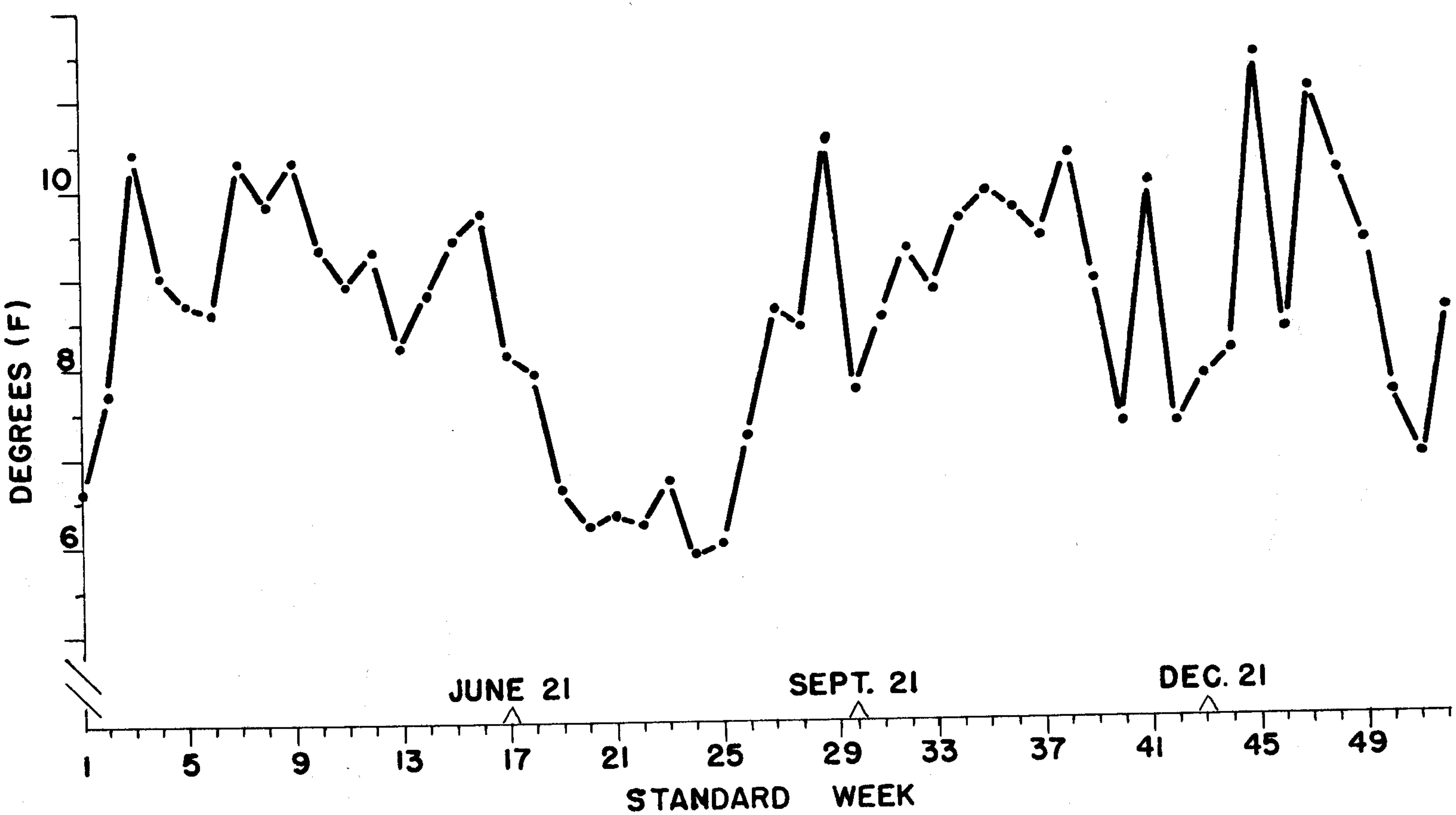

DEGREES (F)
0
20
40
60
JUNE 21
SEPT. 21
DEC. 21
1
5
9
13
17
21
25
29
33
37
41
45
49
STANDARD WEEK


DEGREES (F)
20
10
0
JUNE 21
SEPT. 21
DEC. 21
1
5
9
13
17
21
25
29
33
37
41
45
49
STANDARD WEEK

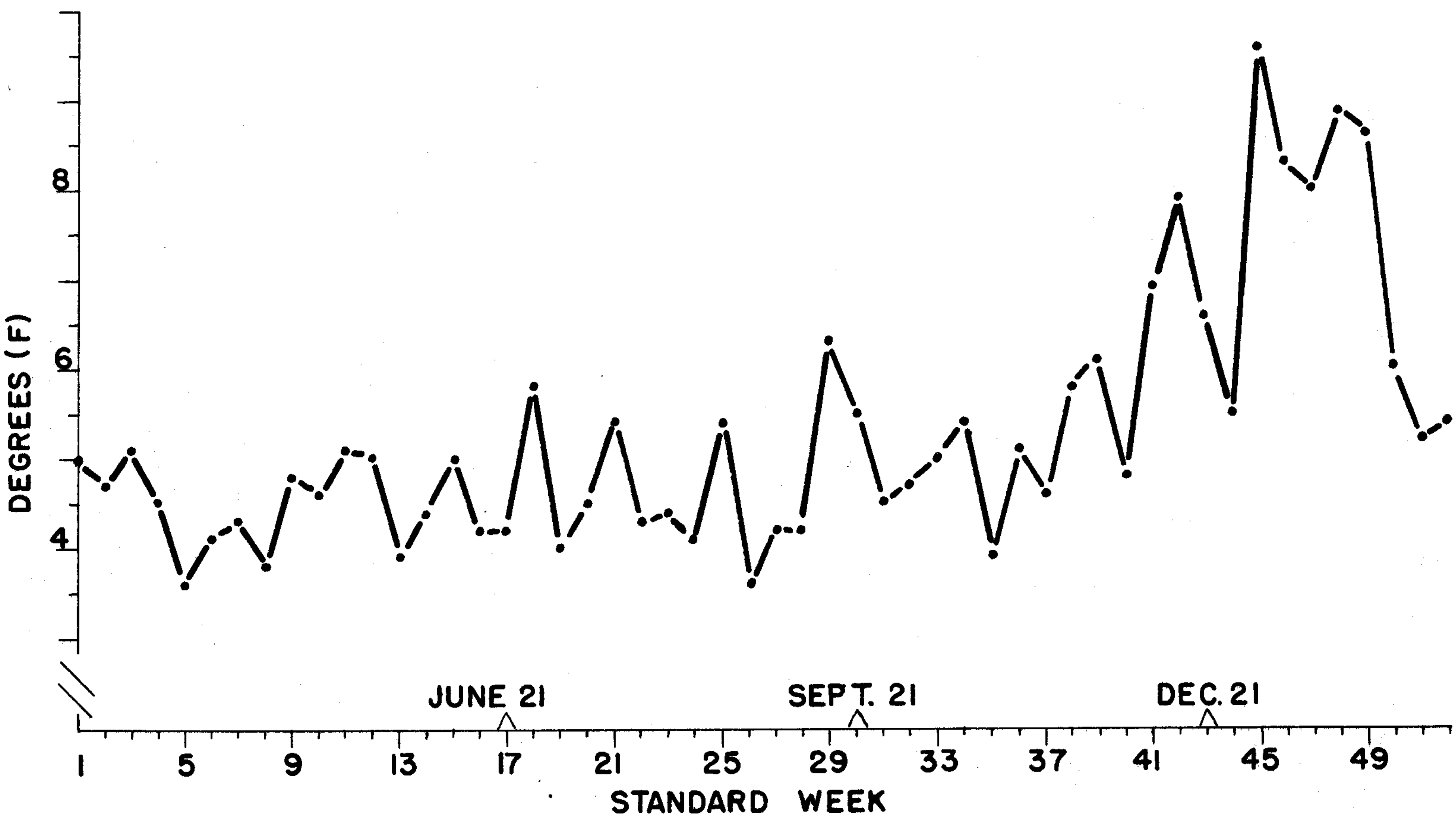


DEGREES (F)
8
6
4
JUNE 21
SEPT. 21
DEC. 21
1
5
9
13
17
21
25
29
33
37
41
45
49
STANDARD WEEK


15.6
16.2
12
10
8
6
DEGREES (F)
JUNE 21
SEPT. 21
DEC. 21
1
5
9
13
17
21
25
29
33
37
41
45
49
STANDARD WEEK



DEGREES (F)
10
8
6
JUNE 21
SEPT. 21
DEC. 21
1
5
9
13
17
21
25
29
33
37
41
45
49
STANDARD WEEK


DEGREES (F)
8
6
4
JUNE 21
SEPT. 21
DEC. 21
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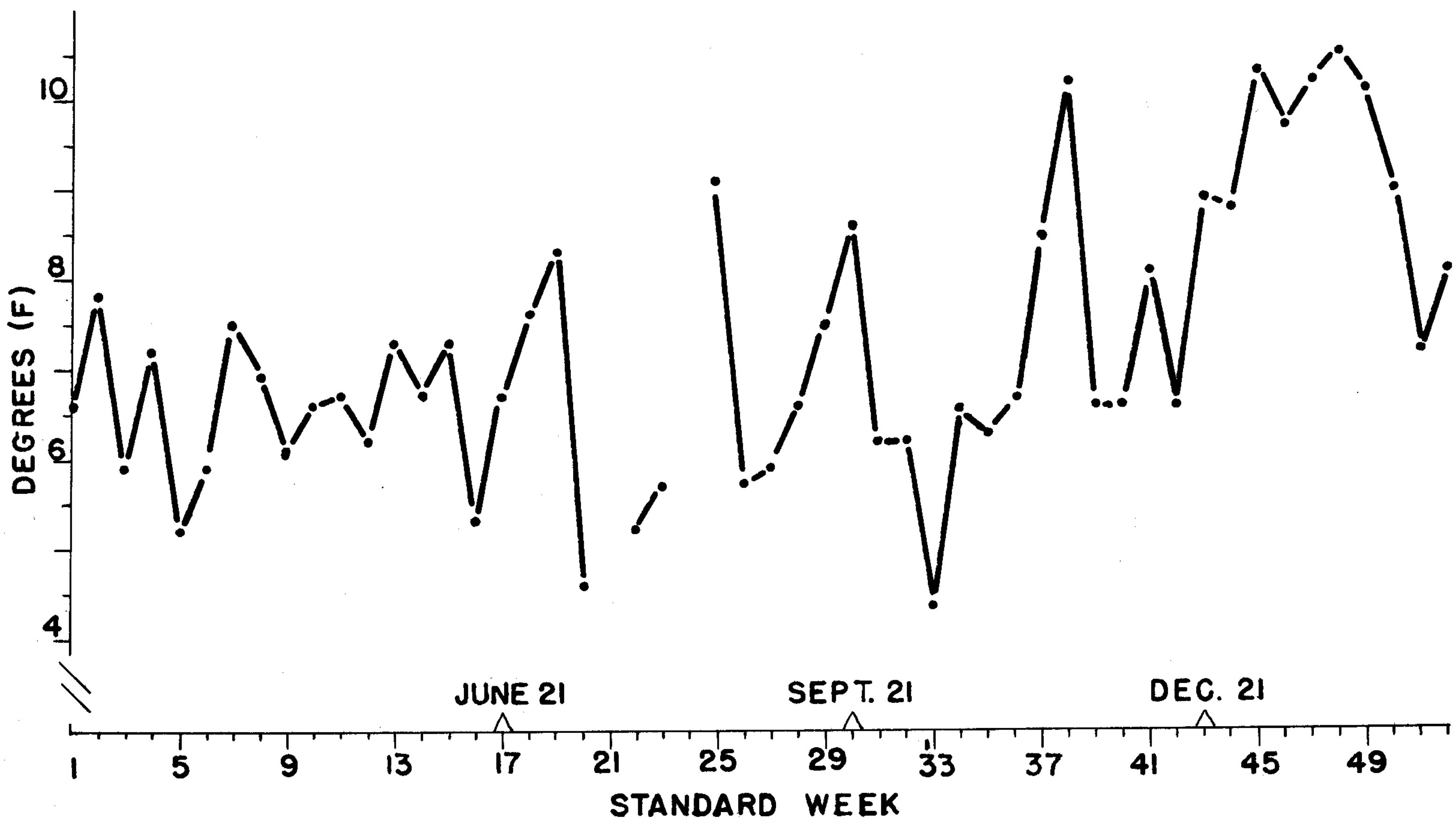
9
13
17
21
25
29
33
37
41
45
49
STANDARD WEEK


DEGREES (F)
10
8
6
4
JUNE 21
SEPT. 21
DEC. 21
1
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13
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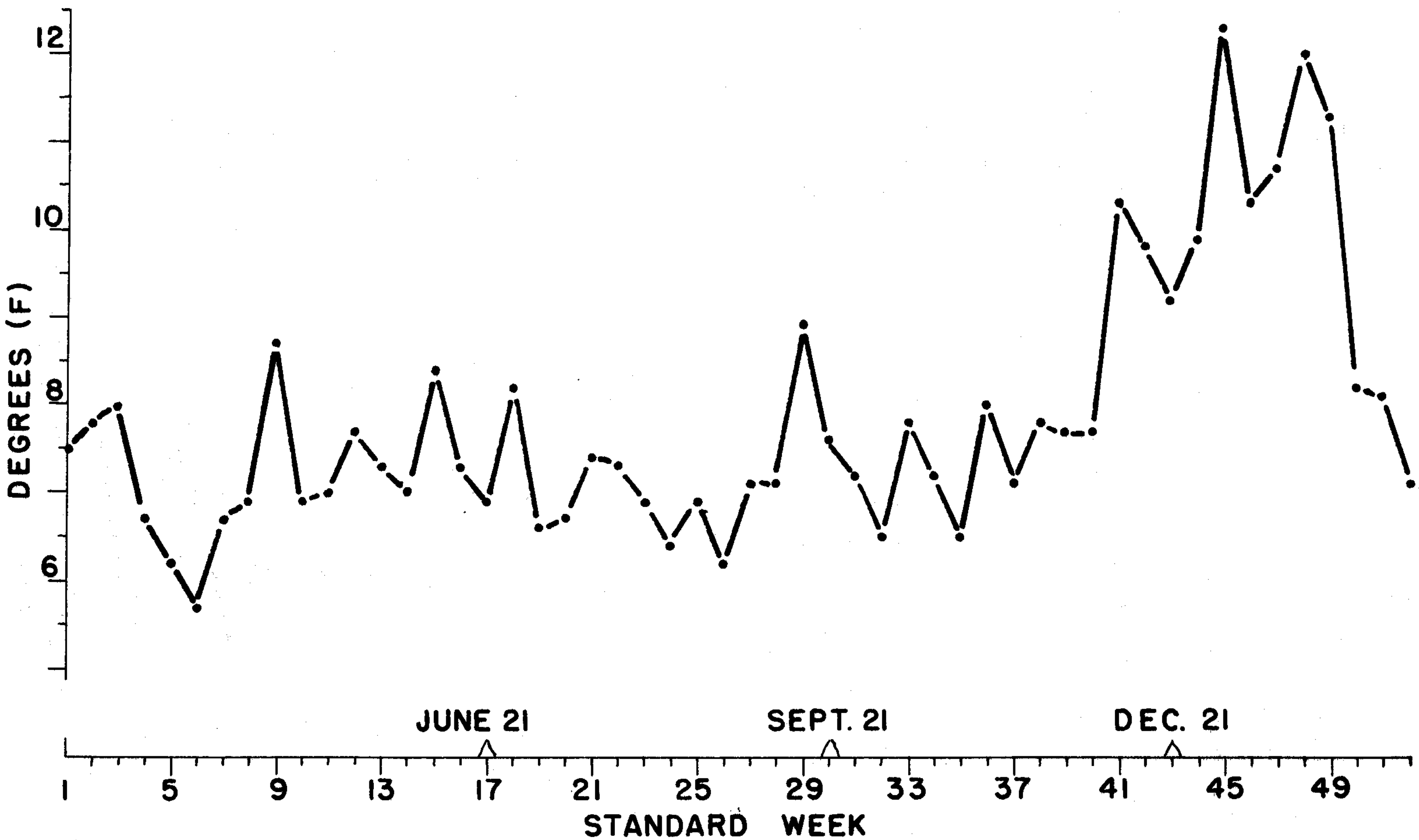
29
33
37
41
45
49
STANDARD WEEK


12
10
8
6
DEGREES (F)
JUNE 21
SEPT. 21
DEC. 21
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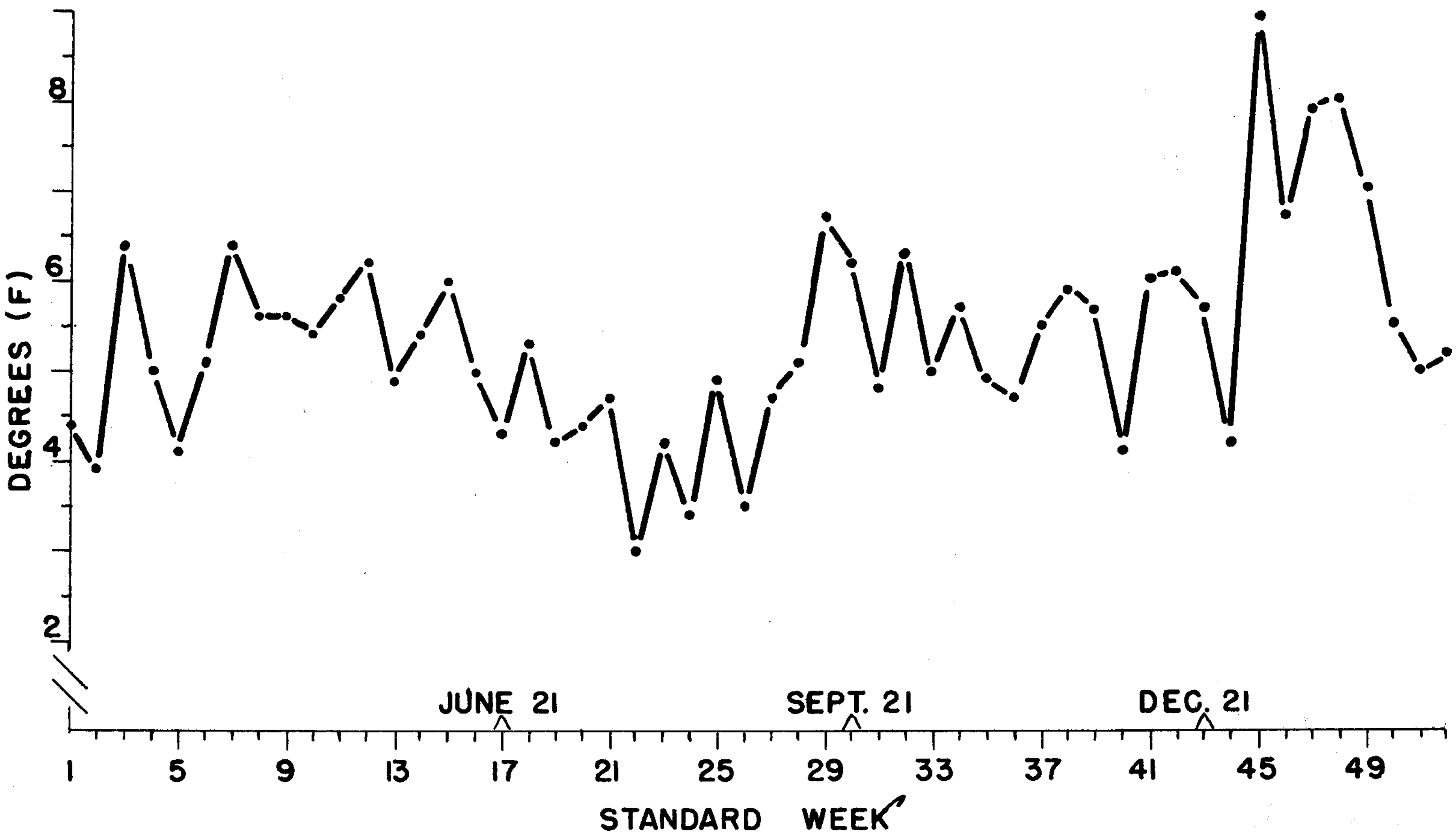
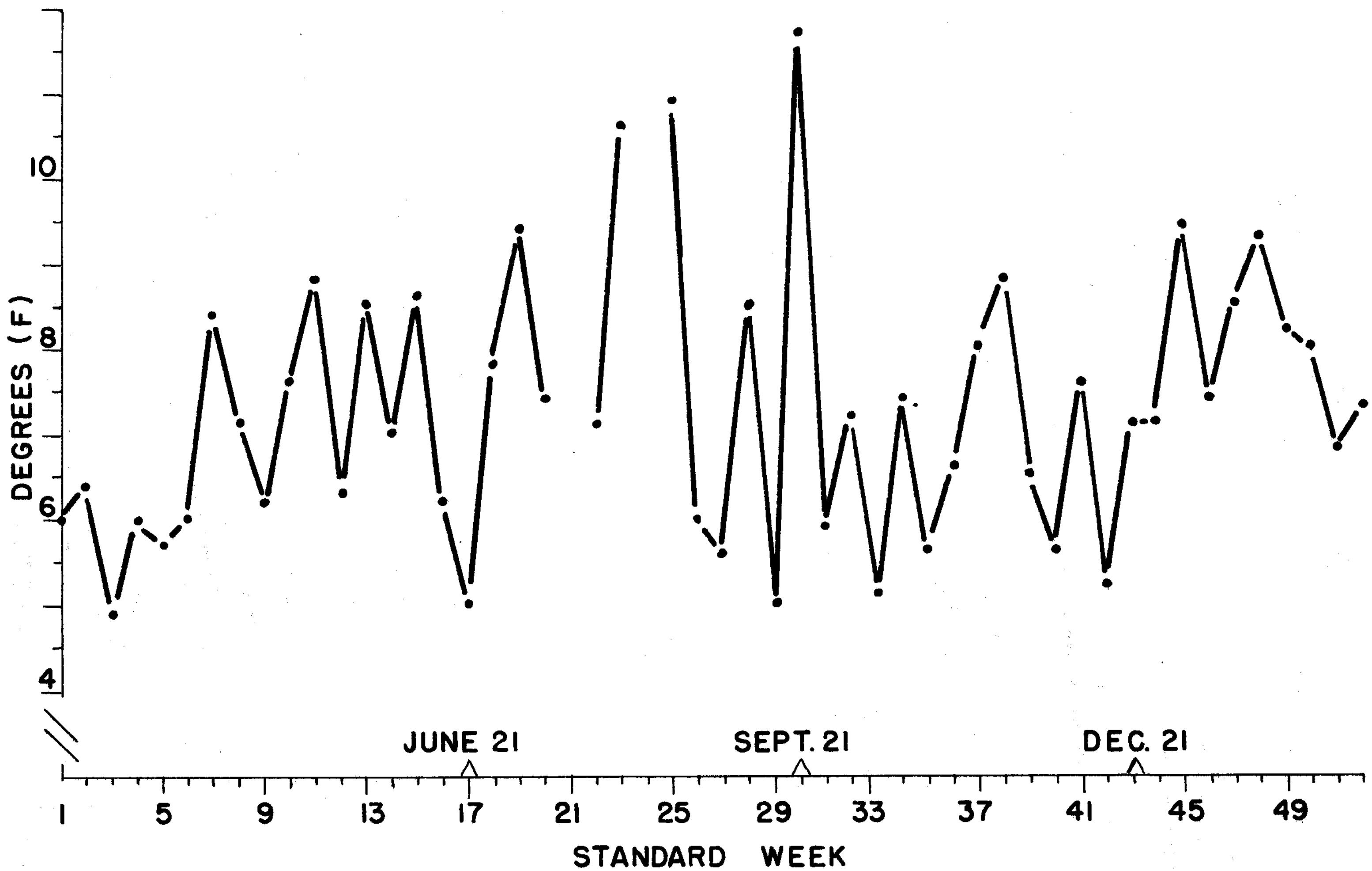
37
41
45
49
STANDARD WEEK

A-9


8
6
4
2
DEGREES (F)
JUNE 21
SEPT. 21
DEC. 21
1
5
9
13
17
21
25
29
33
37
41
45
49
STANDARD WEEK



DEGREES (F)
10
8
6
4
JUNE 21
SEPT. 21
DEC. 21
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29
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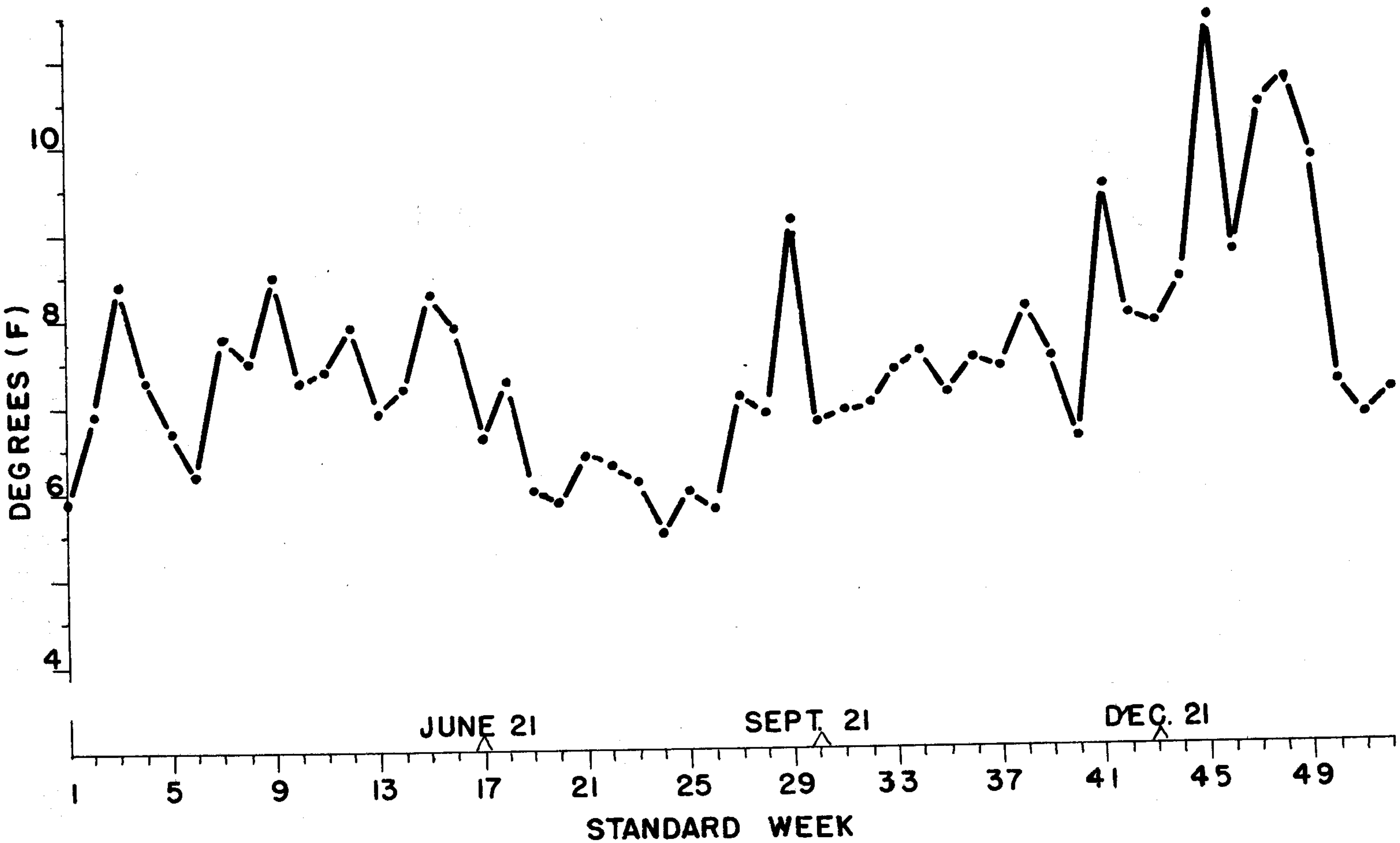
37
41
45
49
STANDARD WEEK



DEGREES (F)
10
8
6
4
JUNE 21
SEPT. 21
DEC. 21
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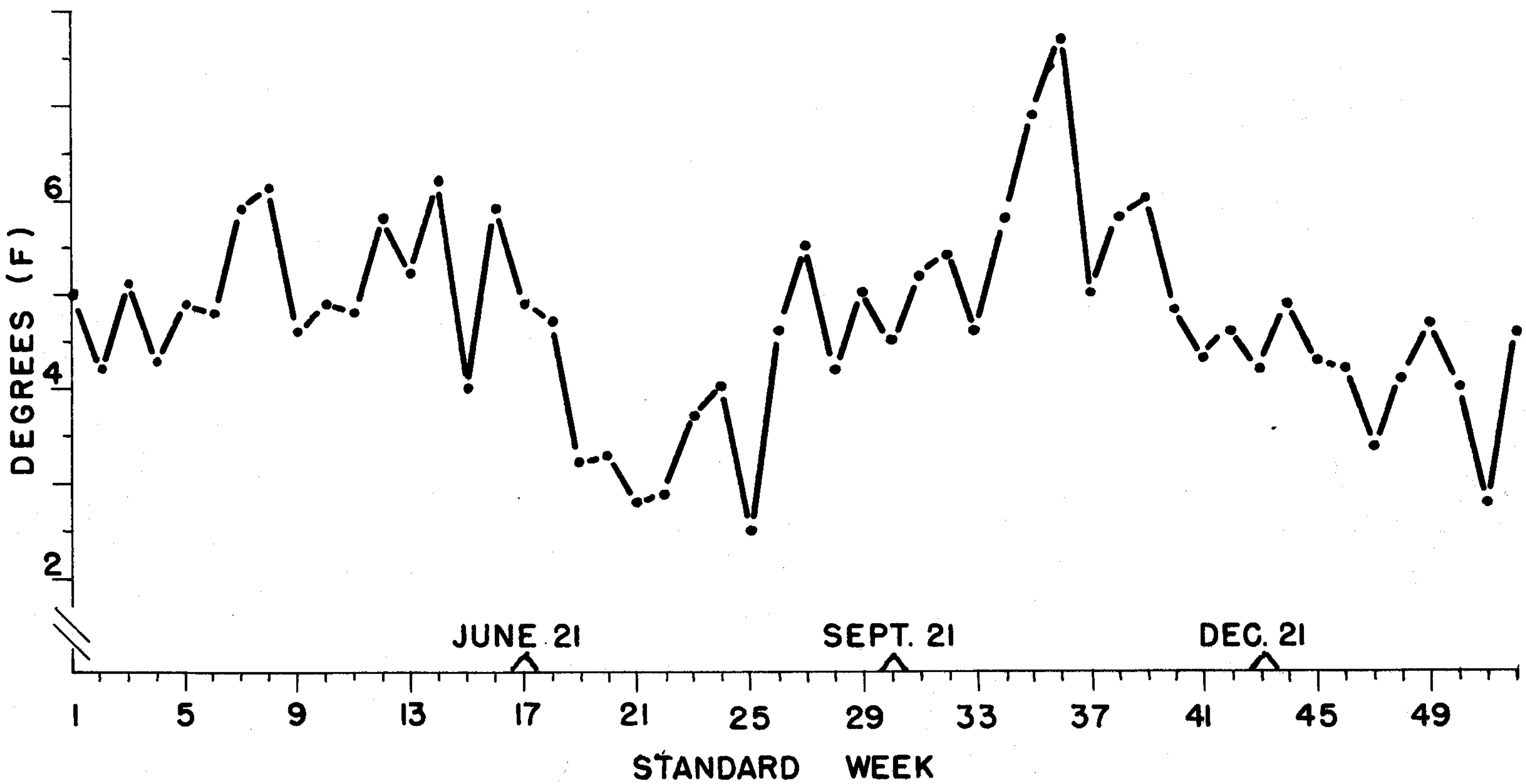
45
49
STANDARD WEEK


DEGREES (F)
6
4
2
JUNE 21
SEPT. 21
DEC. 21
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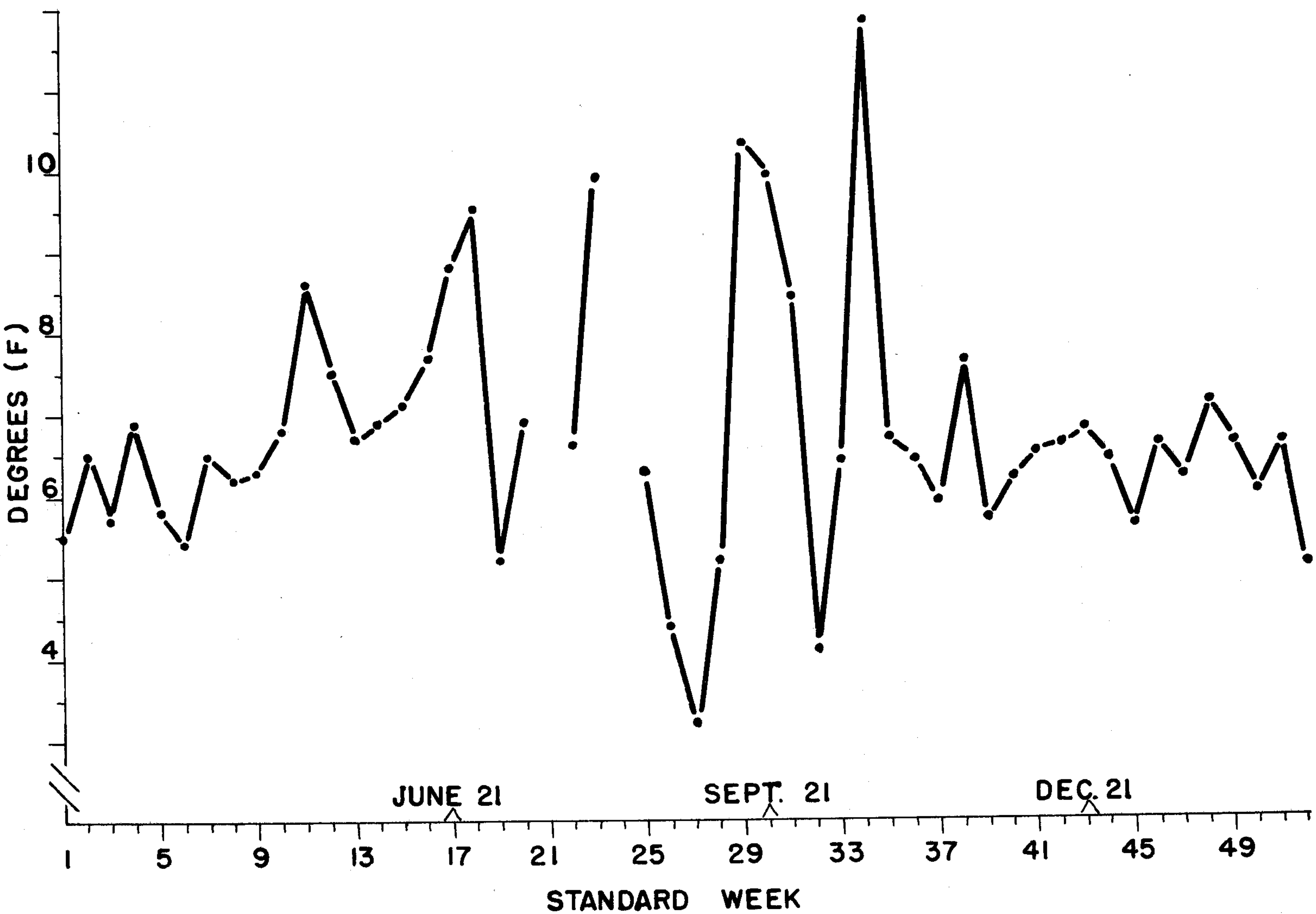
49
STANDARD WEEK


DEGREES (F)
10
8
6
4
JUNE 21
SEPT. 21
DEC. 21
1
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37
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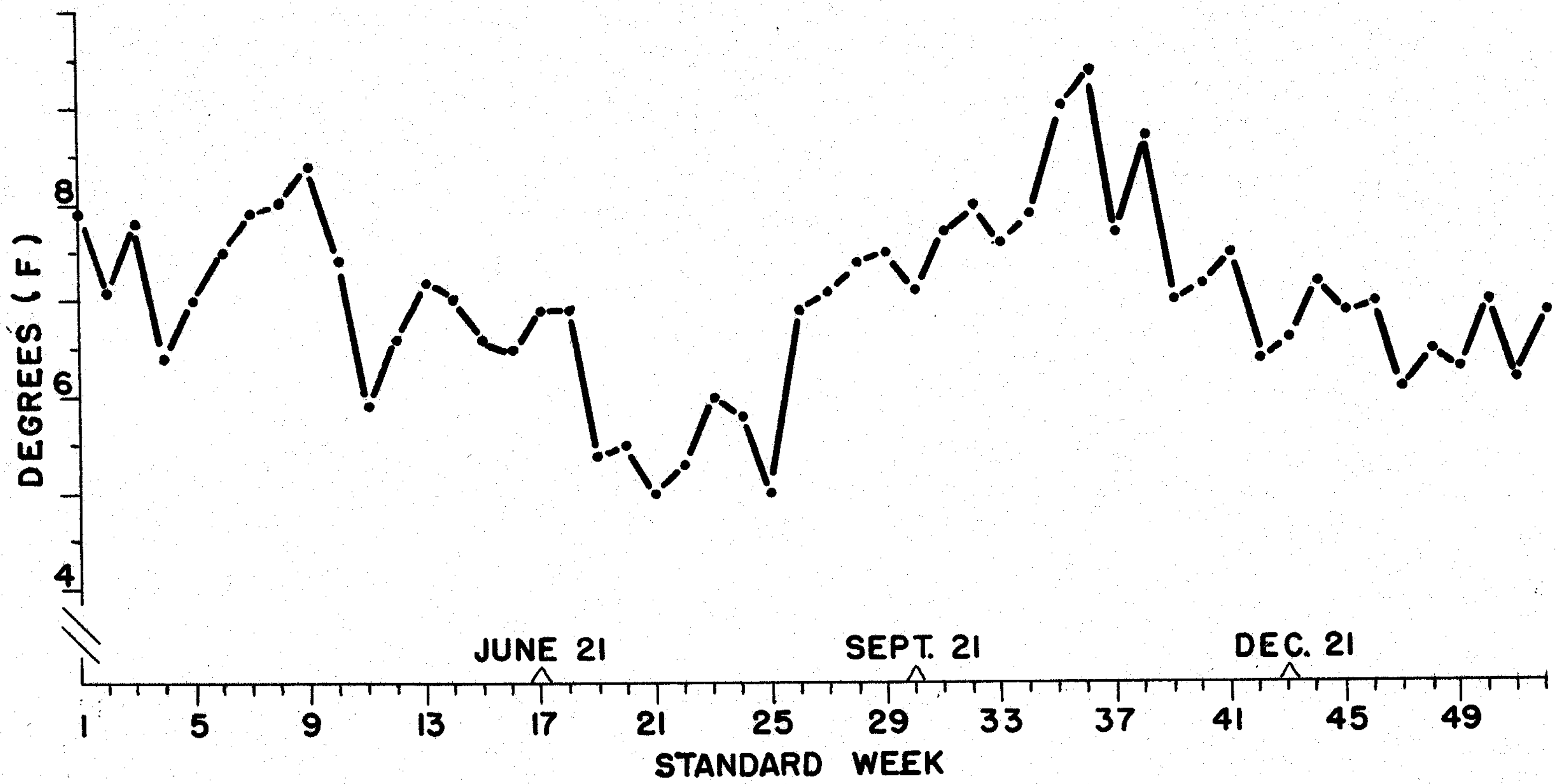
45
49
STANDARD WEEK

A-14



DEGREES (F)
4
6
8
1
5
9
13
17
21
25
29
33
37
41
45
49
JUNE 21
SEPT. 21
DEC. 21
STANDARD WEEK