NOAA TM NWS WR80

A UNITED STATES
DEPARTMENT OF
COMMERCE
PUBLICATION

NOAA Technical Memorandum NWS WR80

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service

Estimation of Number of Days Above or Below Selected Temperatures

CLARENCE M. SAKAMOTO

Western Region

SALT LAKE CITY,
UTAH

October 1972

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U. S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE

NOAA Technical Memorandum NWSTM WR-80

ESTIMATION OF NUMBER OF DAYS ABOVE OR BELOW SELECTED TEMPERATURES

Clarence M. Sakamoto
Weather Service Office
Reno, Nevada

WESTERN REGION
TECHNICAL MEMORANDUM NO. 80

SALT LAKE CITY, UTAH
OCTOBER 1972

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ESTIMATION OF NUMBER OF DAYS ABOVE OR BELOW SELECTED TEMPERATURES

ABSTRACT

Regression equations were developed and graphed to provide an estimate of the number of days in a month the temperature was above or below selected temperature thresholds. These included: the mean number of days when the maximum temperature is equal to or greater than the following temperatures: 65°F, 70°F, 75°F, 80°F, 85°F, 90°F, 95°F, 100°F and when the maximum temperature was less than 32°F. In addition, this study included estimation of the mean number of days when the minimum temperature is equal to or less than the following levels: 0°F, 10°F, 20°F, and 32°F. The procedure involved regressing the probit transformation of the percent of days with the monthly mean maximum or mean minimum temperature. The developed equations were tested for the Columbia Basin states and Nevada. Results indicate that this procedure provides a reliable and rapid method for estimation and gives field climatologists a useful tool to meet users' requests.

I. INTRODUCTION

The "mean number of days" table found readily in monthly national climatological publications is usually associated with four threshold temperatures. These are: (a) the mean number of days when the maximum temperature equals or exceeds 90°F; (b) the mean number of days when the maximum temperature is 32°F or below; (c) the mean number of days when the minimum temperature is equal or less than 32°F; (d) the mean number of days when the minimum temperature is 0°F or less. For comparative purposes over the United States, these threshold temperatures may be valid and useful. In some instances, however, the table for a specific temperature, e.g., 90°F, may not be meaningful when this threshold is not often reached. Other low temperature levels may be of interest. Also, requests are sometimes received for a threshold level not readily tabulated.

Computer facilities have expedited the availability of this type of information, but analysis of daily observations over a long period is still time-consuming. Climatologists need a rapid means of estimating the mean number of days above or below a selected temperature level to meet users' requests and also to provide this information without resorting to analysis of voluminous data at a field station. This study provides a rapid and simple method for estimating the number of days above or below selected threshold temperatures. These temperatures include mean number of days when the maximum temperature is equal to or greater than the following temperatures: 65°F, 70°F, 75°F, 80°F, 85°F, 90°F, 95°F, 100°F and when the maximum temperature is less than 32°F. In addition, this study includes estimation of the mean number of days when the minimum temperature is equal to or less than the following levels: 0°F, 10°F, 20°F, and 32°F.

II. PROCEDURE

The initial procedure involved plotting the percent of days in the month with maximum temperature equal to or greater than the following temperatures: 65, 70, 75, 80, 85, 90, 95 or 100 degrees F, versus the monthly mean temperatures; percent days in the month when the maximum temperature is equal to or less than 32 degrees F, versus the mean temperature; and the percent of days with minimum temperature equal to or less than the following temperature thresholds: 32, 20, 10 or 0 degrees F versus the mean minimum temperature. This was done for the Columbia Basin states and Nevada. Percentage of the days in a month was utilized to provide a homogenous scale for all months involved. An example of the plot of percent of days in month with maximum temperature equal to or greater than 65 degrees versus monthly mean maximum temperature is shown in Figure 1. The ID = 65 is the identification of the plot; NO = 356 represent the sample size, which is not plotted completely because some of the data points represent more than one datum point. The mean temperature (average of maximum and minimum) was also plotted to explore the relationship, but the resulting variation was greater than that of using only the maximum or minimum temperature. Therefore, the mean temperature was not used.

A study of the plots revealed that the curve is sigmoid and suggests a normal distribution. Analysis based directly on this distribution would have been simple, but other factors need be considered. (a) There are temperature limits above or below which the number of days is zero or 100 percent of the days in a month. (b) These need to be eliminated to minimize a bias in a prediction line; data available for analysis in some instances may not be distributed to provide samples covering a sufficiently broad range. Therefore, the mean and variance, even though possible to calculate, may be meaningless.

It was hypothesized that if the range and distribution of samples were sufficient, the curve would follow a normal distribution, but because of (b) in the previous paragraph, another approach was necessary to obtain a prediction model. This approach involved the probit transformation of the original data, in this case, the percent of days in a month. Discussion of the probit transformation is detailed by Finney (2). An example of the data plot of the transformed data for the percent of days when the maximum temperature is greater than 65°F is given in Figure 2. Essentially, the probit transformation linearizes the normal sigmoid curve to obtain a straight line. (See Figure 3.)

In this study, the transformed data was regressed on temperature, using the least squares method. The result was a linear regression equation for each of the threshold temperatures. For some threshold levels, e.g., 90°F, 95°F, 100°F, 0°F, the same size was insufficient to provide a stable equation. Therefore, it was decided to combine the data for all states (Idaho, Oregon, Washington, Nevada, and parts of Montana) and run a combined model at each level in addition to a model for each level at each state.

III. DATA

Data for this study were extracted from the Climatological Handbook, Columbia Basin States, Volume I, Parts A and B (this handbook covered the states of Idaho, Oregon, Washington, and parts of Montana) (3, 4). For Nevada, data for the sites were determined by examining daily temperature observations (5). These states were selected to cover the spectrum of temperature range which has potential interest. Identical period data were not included in this analysis. Sites selected were based on length of record available which consisted of at least 29 years for the Columbia Basin states and at least 20 years for Nevada, as well as the general coverage of the states involved. Approximate location and name of the stations are shown in Figures 4, 5, 6, and 7.

IV. RESULTS

Tables 1 through 4 are the summary of the final regression equations based on the transformed data (percent of days) for the individual states. Note that the percent of variation explained by the model (R^2) is generally excellent, except for the extreme threshold values, i.e., 95°F, 100°F, and 0°F. For the combined states model (Table 5), significant improvement is achieved. This results from combining data which cover a broader temperature range and, hence, data which cover a larger range of percent of days above or below a specified threshold. This suggests that for the states involved in this study, the combined model is a better predictor than the individual model for temperature levels 95°F, 100°F, and 0°F. For other thresholds, it is recommended that the individual model for each state be applied.

The models were subsequently tested on an independent sample for independent data sites (Table 6). The observed and computed values (probit transformation) were compared, using the correlation coefficient as a measure of their association. Again, the poorest association was obtained with the extreme threshold levels, 95°F, 100°F, and 0°F.

To expedite the analysis where computer facilities may not be available, the models were graphically charted. These are shown in Figures 8 through 17. Figures 8 and 9 are for Idaho and northwest Montana; Figures 10 and 11 for Nevada; Figures 12 and 13 for Oregon; Figures 14 and 15 for Washington, and Figures 16 and 17 are for the combined states.

These graphs are used to determine the probit value (dependent variable). For example, Figure 8 is used to determine the probit value for the number of days when the maximum temperature equals or exceeds selected temperatures at Idaho and northwest Montana. The mean monthly maximum temperature on the left ordinate is used as the independent variable to determine the probit value. For 32°F (number of days when the maximum temperature is less than 32°F), the ordinate scale to the right is used. Having determined that probit value, Figure 18 is used to retransform the probit values to either the precent of days (left ordinate scale) or the approximate number of days (right ordinate scale). For example, in Figure 8, if the mean monthly maximum temperature was 90°F and it was desired to determine the mean number of days when the maximum temperature was 85°F or higher, proceed right from the left ordinate at 90°F until the line '85' is intersected. From the point of intersection, proceed down until the value is found on the probit scale (abscissa). In this case, the value is 5.7. Enter 5.7 in Figure 18 on the abscissa and proceed upward until the curved line is intersected. The value for percent of month is 75 percent; for the number of days with a month having 30 days, it is 22.5 days.

Values for the number of days when the minimum temperature is below selected levels is similarly determined. For example, Figure 9 is used to find the probit value for Idaho and northwest Montana. The value is then entered in Figure 18 for the desired information.

The confidence interval for the estimate of a mean is calculated, in the case of the 95 percent confidence interval (C.I.), by:

$$C.I. = \bar{y} + bx \pm t_{.05}\, s_{y.x} \sqrt{\frac{1}{n} + \frac{x^2}{\Sigma x^2}} \qquad (1)$$

where the term $\bar{y} + bx$ is the estimated mean determined previously in the above example; $x = X - \bar{x}$ where $\bar{x}$ is the mean and X is the observed independent variable (the observed mean maximum or mean minimum temperature); Σx^2 is the corrected sum of squares for X from which the model was derived; $s_{y.x}$ is the standard deviation of the estimate y and $t_{.05}$ is student's 't' for n-2 degrees of freedom. These values have been tabulated for each model (See Tables 8 through 12). Equation (1) is used in the case where a value of mean temperature is derived from analysis of several years. In some cases, interest may be on a particular year's data. To determine the confidence interval for this, the following is used:

$$C.I. = \bar{y} + bx \pm t_{.05}\, s_{y.x} \sqrt{1 + \frac{1}{n} + \frac{x^2}{\Sigma x^2}} \qquad (2)$$

For example, if the 90°F occurred this year, the estimated mean number of days determined earlier is 22.5 days (probit value of 5.7). From Table 8 for Idaho and northwest Montana, and for temperature level 85°F, $t_{.05} = 1.998$; $s_{y.x} = .149$; $n = 95$; $\bar{x} = 77.6$ and $\Sigma x^2 = 5118.6$. Therefore, the 95 percent confidence interval is:

$$\text{C.I.} = 5.7 \pm 1.998(.149)\sqrt{1 + \frac{1}{95} + \frac{(91-77.6)^2}{5118.6}} \qquad (3)$$

or between 5.4 and 6.0 probit value. This corresponds to between 19 and 25 days for a month with 30 days. Other state values are shown in Tables 9 through 12.

Examination of the regression coefficients (slope) of the models suggest they may be the same. Two slopes may be compared with the student's t with $n_1 + n_2 - 4$ degrees of freedom. The test was conducted for threshold temperatures 65, 70, 75, 80, 85, and 90 F only. The test is:

$$t = \frac{b_1 - b_2}{\sqrt{s_p^2 \left(\frac{1}{\Sigma x_1^2} + \frac{1}{\Sigma x_2^2}\right)}} \qquad (4)$$

where b_1 and b_2 are the regression coefficients for samples 1 and 2 respectively; Σx_1^2 and Σx_2^2 are the corrected sum of squares for the respective samples and s_p^2 is the pooled variance determined by:

$$s_p^2 = \frac{\{\Sigma y_1^2 - [(\Sigma x_1 y_1)^2 / \Sigma x_1^2]\} + \{\Sigma y_2^2 - [(\Sigma x_2 y_2)^2 / \Sigma x_2^2]\}}{n_1 - 2 + n_2 - 2} \qquad (5)$$

If t in equation (4) is less than the tabulated t with $n_1 + n_2 - 4$ degrees of freedom at the .05 level of significance, it is concluded that the slope of the two lines are the same.

This test was conducted for the largest and smallest regression coefficient value for each model from 65 degrees to 90 degrees F. The statistical results show that the slopes between the largest and smallest value were significantly different and, hence, could not be considered to have the same slope. Consequently, for the samples used in this study, it is recommended that the slope for each individual model be retained in the prediction equation. One possible explanation for the surprising statistical difference is the small range dealt with for the probit values, which range from about 3.5 to 7.5 (see Figure 3).

V. COMPUTER ANALYSIS

Bliss (1) prepared a table of the relationship between percentages and probits. When plotted graphically, the relationship appears as in Figure 19. In the computer program, the curve in Figure 19 was divided into three sections: (a) 1.0 to 29.0 percnet, (b) from greater than 29.0 percent to 70 percent, (c) from greater than 70.0 percent to less than or equal to 99.9 percent. A model was developed between percentages and probits for each section of the curve. For curve (a), a logarithmic model was developed,

$$Y = 2.51573 + .547465 \ln X \tag{6}$$

where Y is the probit and X is the percentage. The coefficient of determination (R^2) was 98.61 percent which means that the data "explained" is .9861 of the variation of the data around the model. For curve (b), a linear model gave the best fit:

$$Y = 3.71121 + .0257758\ X \tag{7}$$

R^2 was .9998. For curve (c), the exponential models were attempted. The 4th polynomial yielded the best fit with $R^2 = .9855$.

$$Y = 1074.32 - 51.8832\ X + .940684\ X^2 - .00755276\ X^3 + .0000226766\ X^4 \tag{8}$$

Although relatively laborious to calculate by hand, computer-usage with these models posed no problem.

As indicated previously, all values of 0% or 100% of month were not included in the analysis of the regression model.

Each card (one card per month) included the mean maximum, mean minimum and mean temperature and the number of days for each of the threshold temperatures.

VI. CONCLUDING REMARKS

The procedure developed in this study provides a convenient method for estimating the number of days in a month with temperatures above or below selected temperature thresholds. The only variable necessary is the mean monthly maximum or the mean minimum temperature.

The procedure can be used to develop models for states other than those included in this study. It is suggested, however, that the combined model developed in this study can be utilized for gross value estimation at other locations.

The regression coefficients from 65°F to 90°F are similar in magnitude, and in some cases, identical. However, analysis of the data show that the slopes (regression coefficients) cannot statistically be considered identical to each other.

VII. ACKNOWLEDGMENT

Suggestions and comments offered by the Scientific Services Division and Regional Climatologist, Western Region Headquarters, are appreciated.

VIII. REFERENCES

1. BLISS, C. I., "The Calculation of the Dosage-Mortality Curve", Annals of Applied Biology, Vol. 22, pp. 134-167, 1935.

2. FINNEY, D. J., Probit Analysis, A Statistical Treatment of the Sigmoid Response Curve, Second Edition, Cambridge at the University Press, p. 318, 1966.

3. STERNES, G. L., Climatological Handbook, Columbia Basin States - Temperature, Vol. I, Part A, June 1969.

4. STERNES, G. L., Climatological Handbook, Columbia Basin States - Temperature, Vol. I, Part B, July 1969.

5. Climatological Data - Nevada, Weather Bureau, U. S. Department of Commerce, 1941-1970.

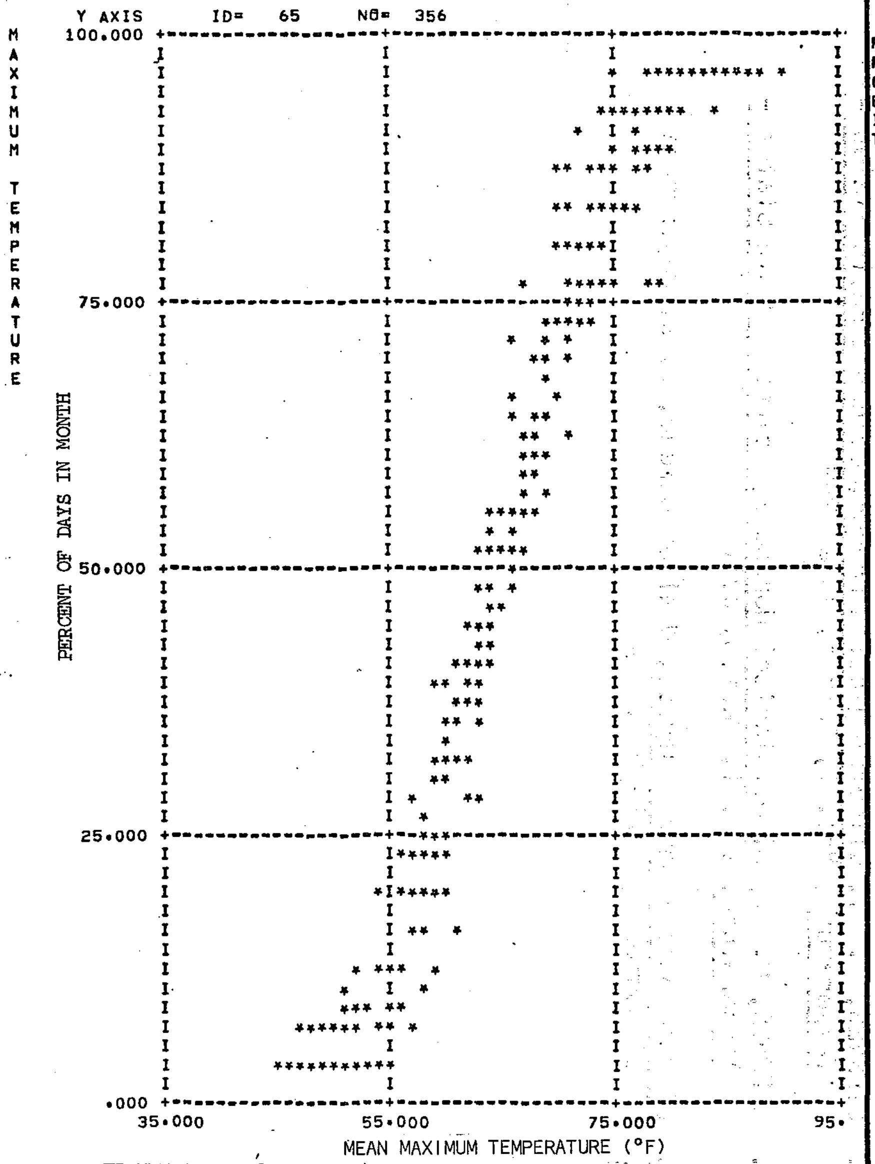

FIGURE 1. SAMPLE PLOT OF PERCENT OF DAYS IN A MONTH WHEN MAXIMUM TEMPERATURE IS EQUAL TO OR GREATER THAN 65°F VERSUS MEAN MAXIMUM TEMPERATURE (°F).

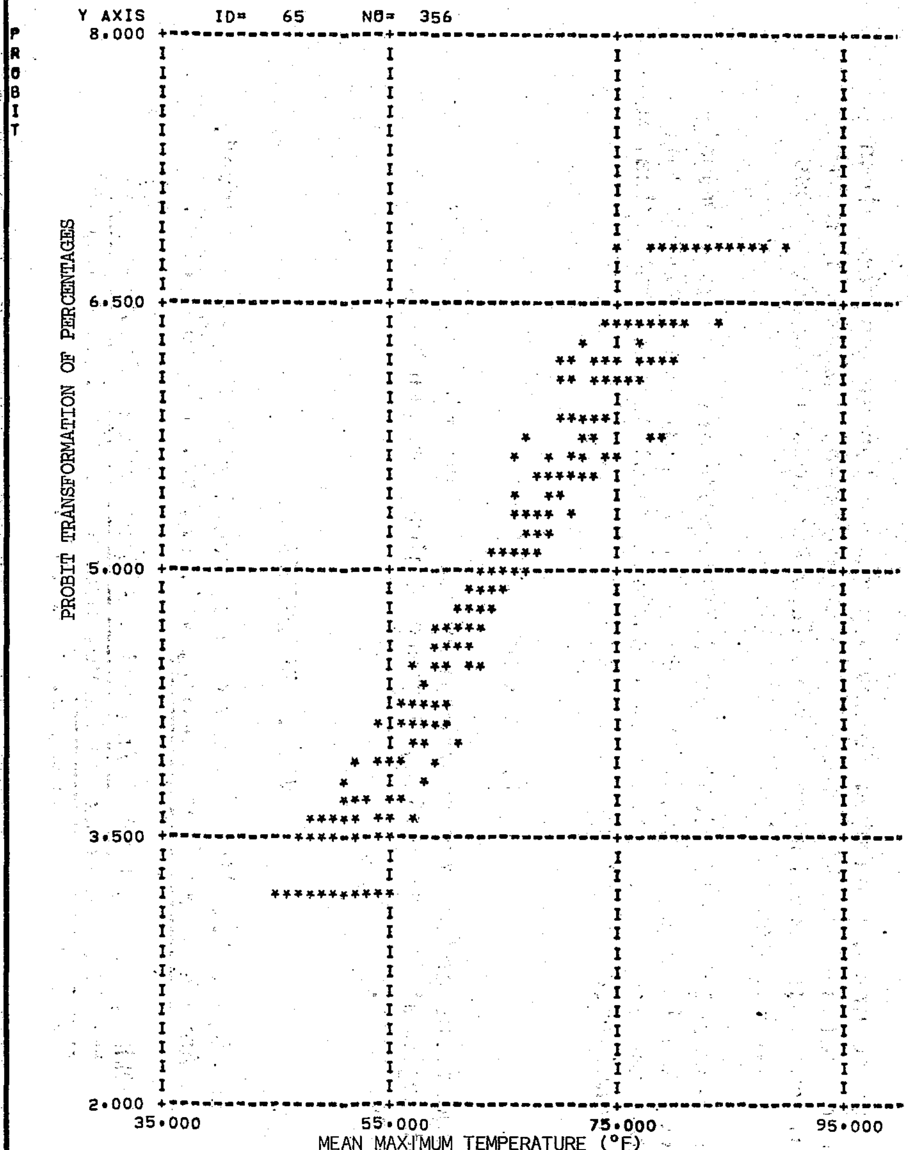

FIGURE 2.--PROBIT TRANSFORMATION OF THE NORMAL SIGMOID CURVE SHOWING THE RELATIONSHIP BETWEEN MEAN TEMPERATURE AND PERCENTAGE.

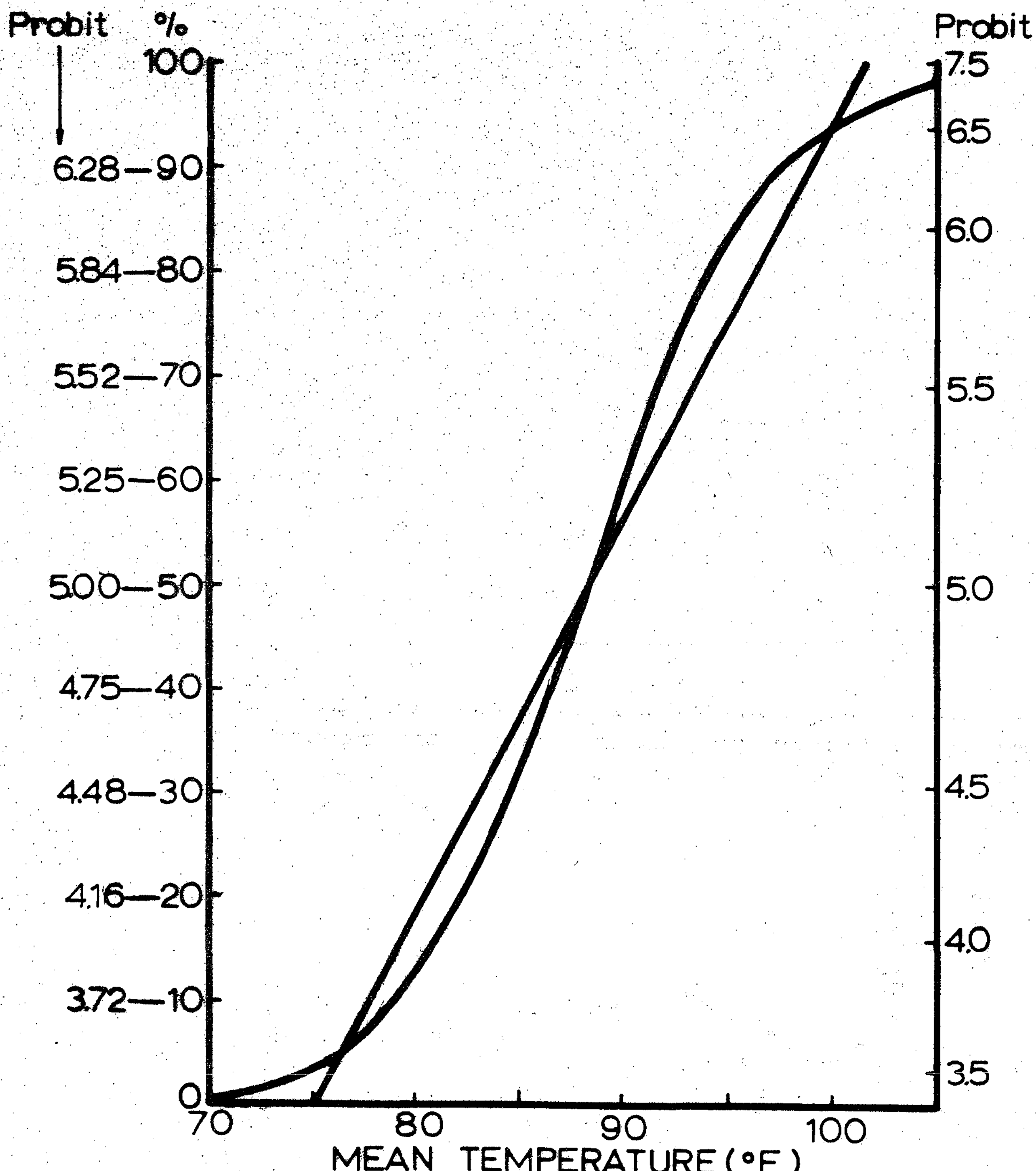

FIGURE 3. SAMPLE PLOT OF MEAN TEMPERATURE VERSUS PROBIT TRANSFORMATION OF PERCENTAGES.

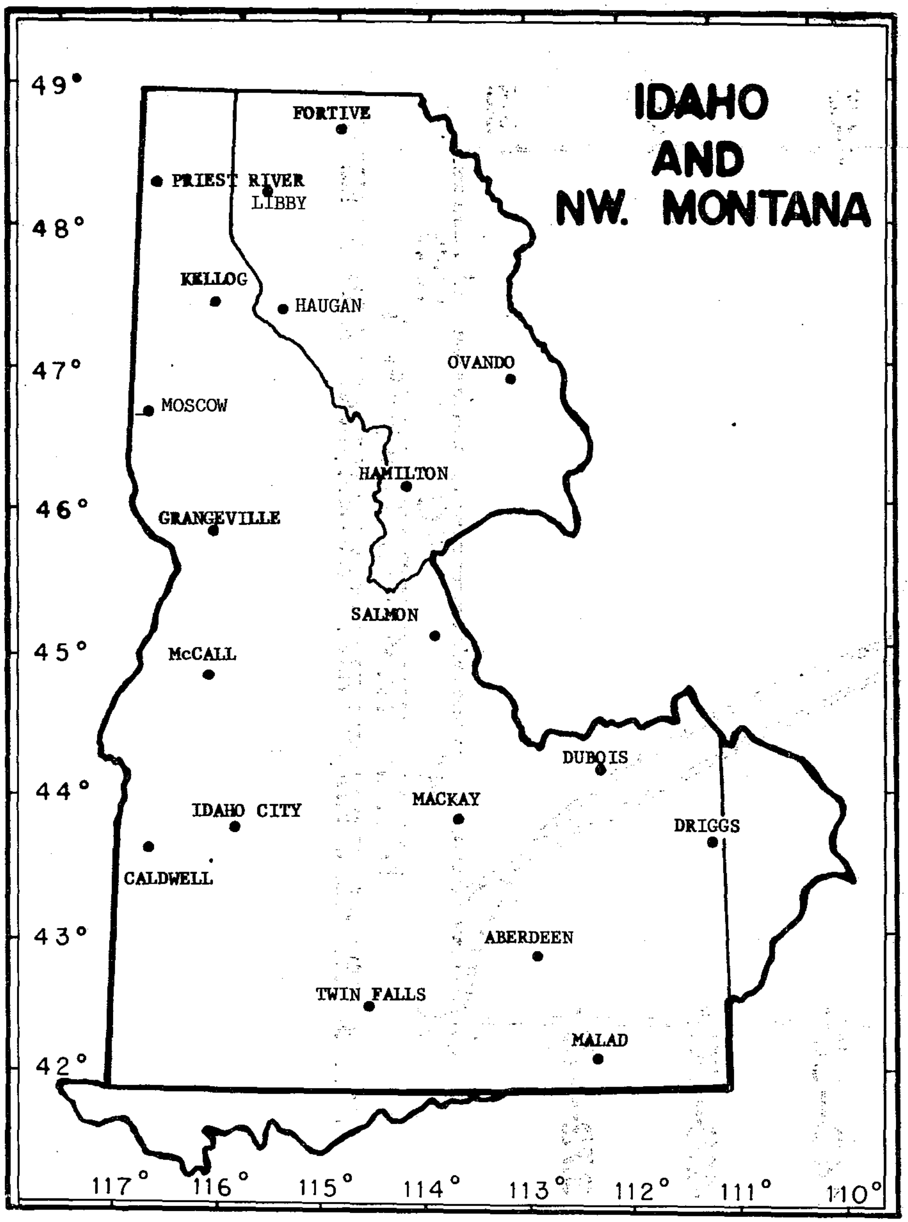

FIGURE 4. LOCATION OF STATIONS IN IDAHO AND NORTHWESTERN MONTANA USED TO DEVELOP REGRESSION MODEL.

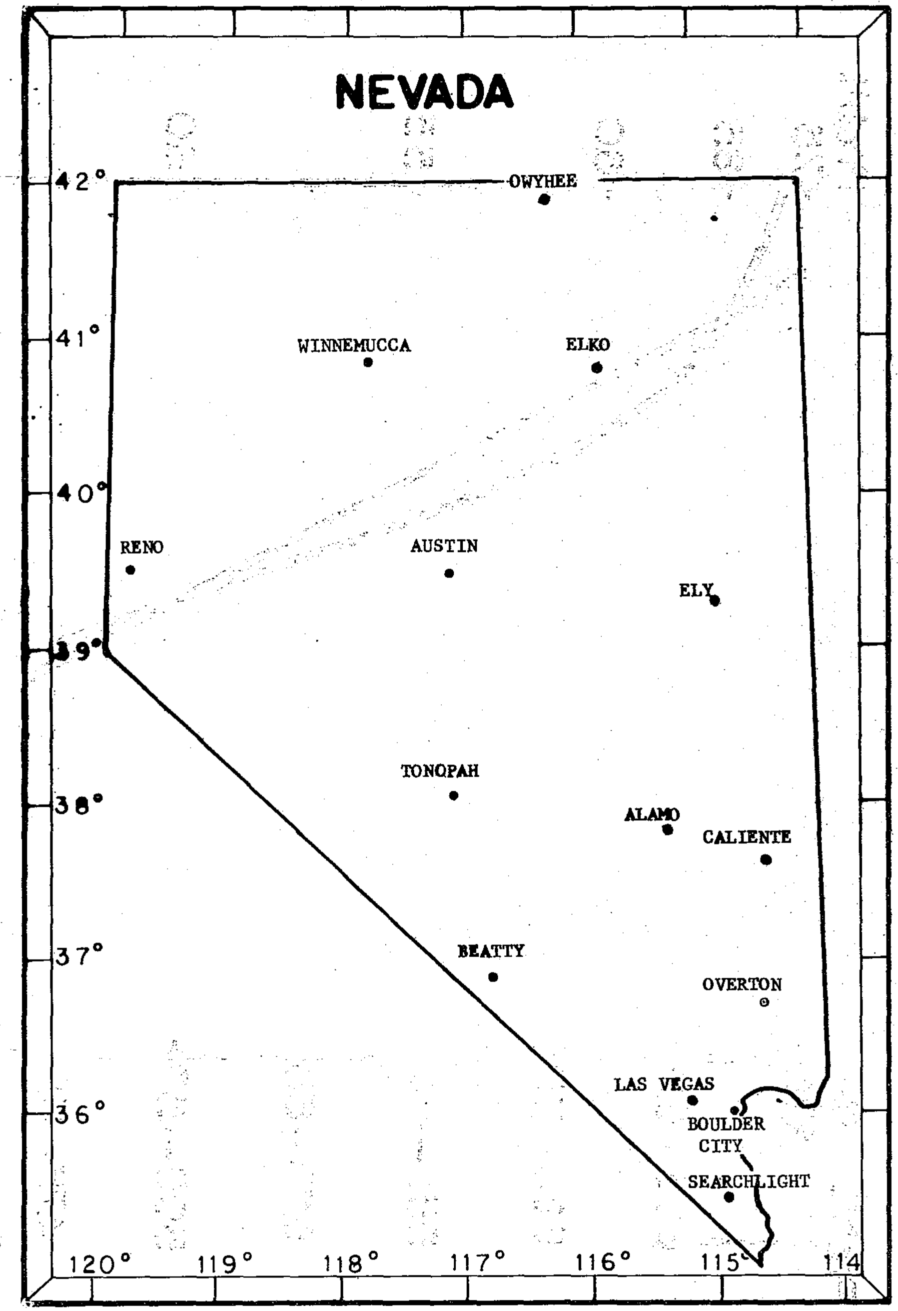

FIGURE 5. LOCATION OF STATIONS IN NEVADA USED TO DEVELOP REGRESSION MODEL.

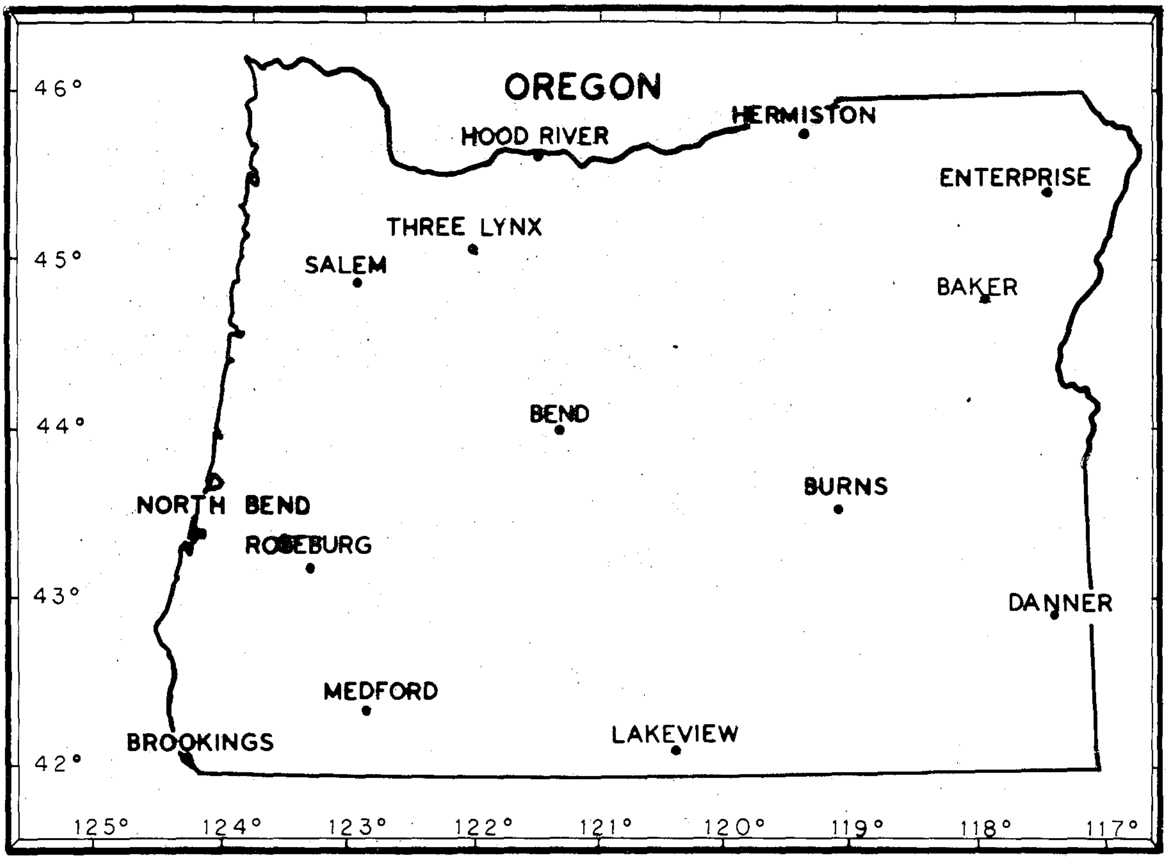

FIGURE 6. LOCATION OF STATIONS IN OREGON USED TO DEVELOP REGRESSION MODEL.

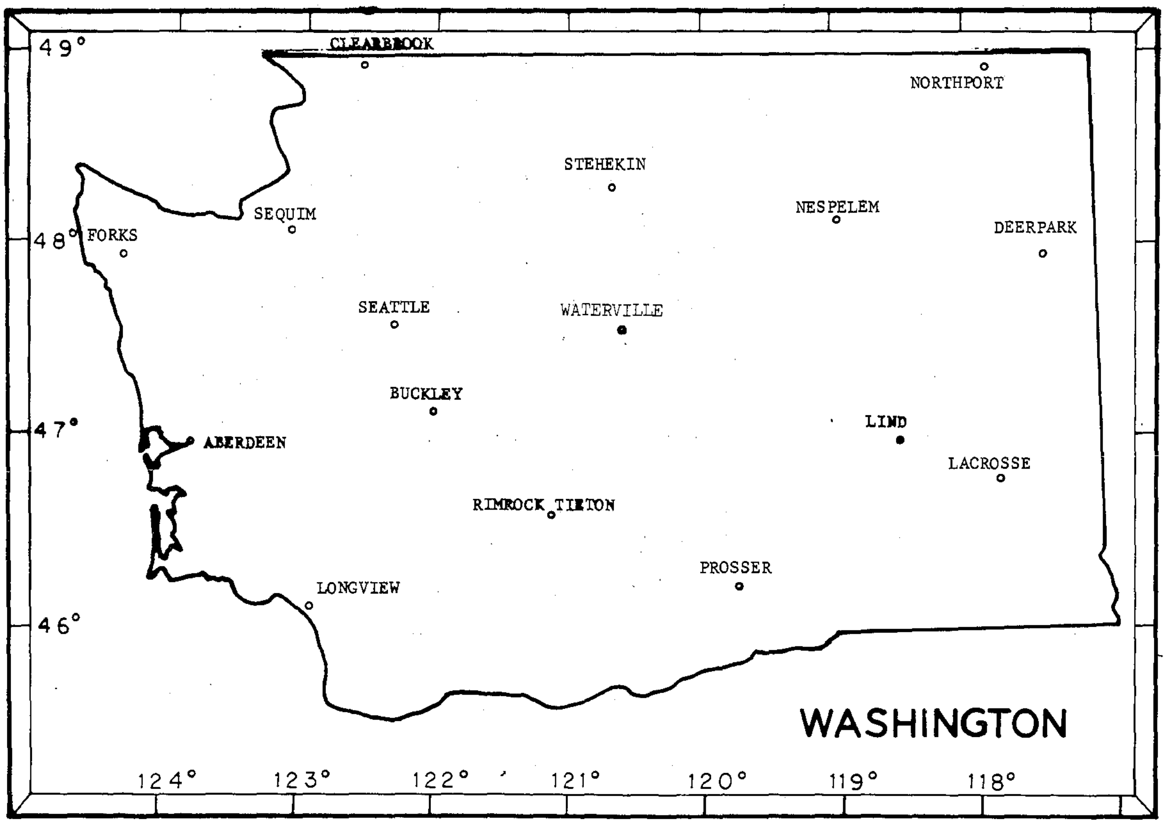

FIGURE 7. LOCATION OF STATIONS IN WASHINGTON USED TO DEVELOP REGRESSION MODEL.

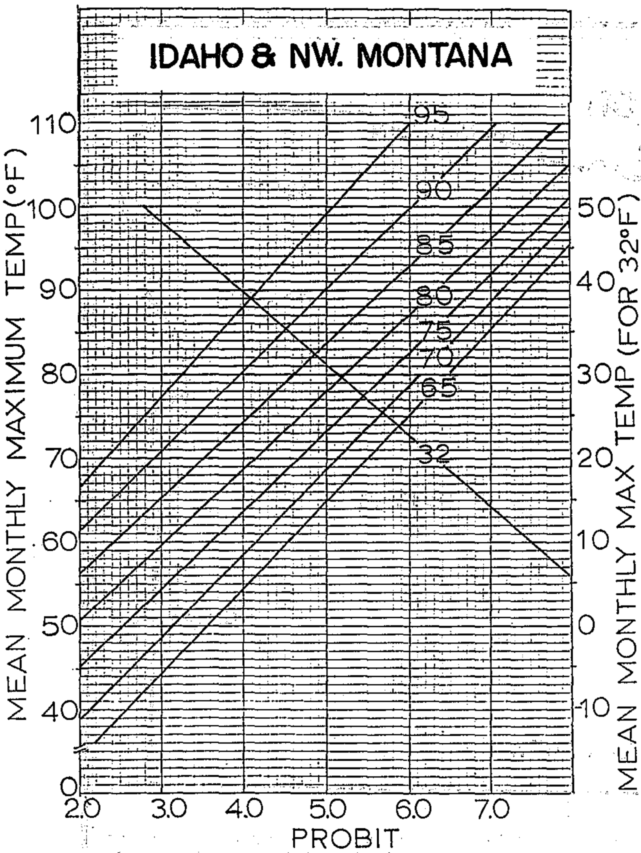

FIGURE 8. REGRESSION LINE RELATING MEAN MONTHLY MAXIMUM TEMPERATURE WITH PROBIT FOR IDAHO AND NORTHWESTERN MONTANA.

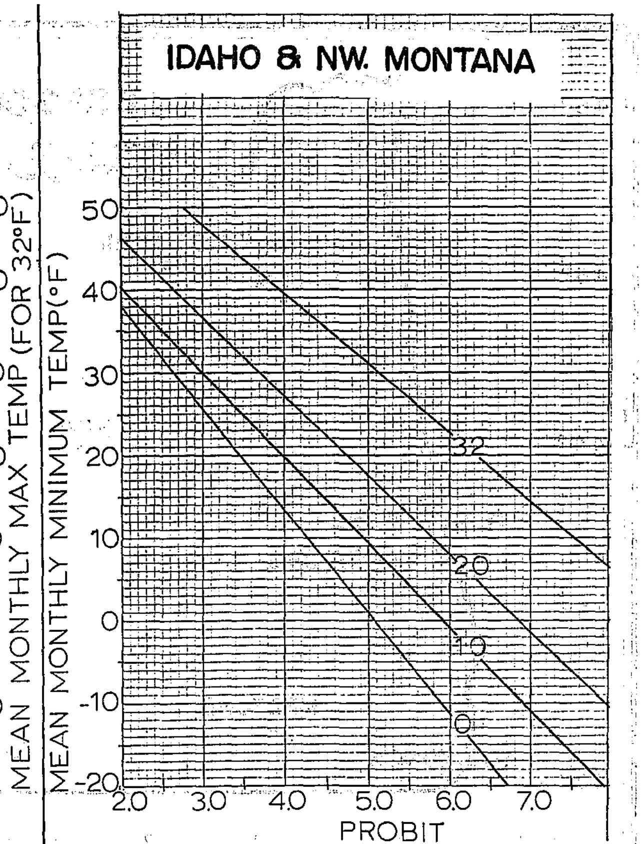

FIGURE 9. REGRESSION LINE RELATING MEAN MONTHLY MINIMUM TEMPERATURE WITH PROBIT FOR IDAHO AND NORTHWESTERN MONTANA.

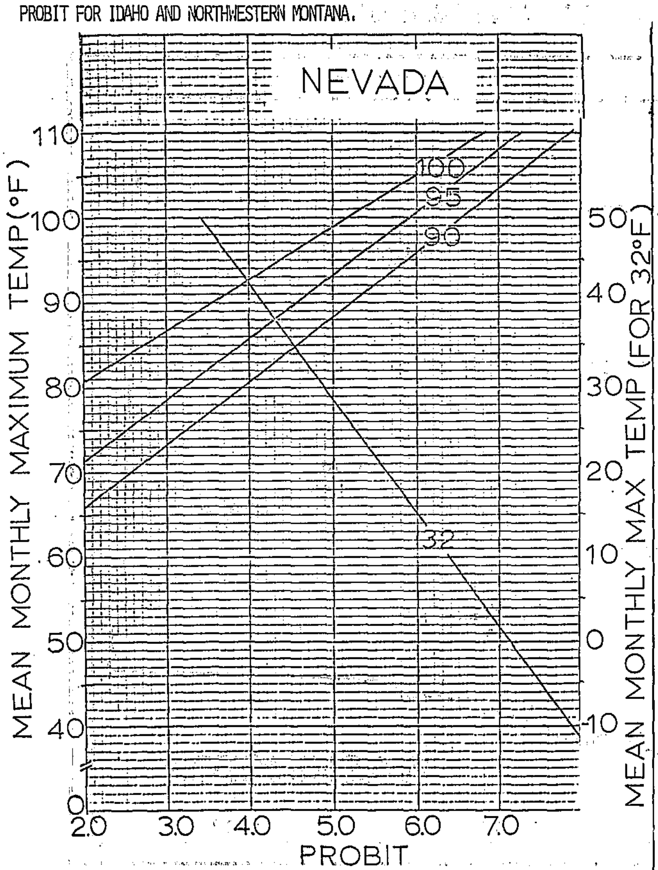

FIGURE 10. REGRESSION LINE RELATING MEAN MONTHLY MAXIMUM TEMPERATURE WITH PROBIT FOR NEVADA.

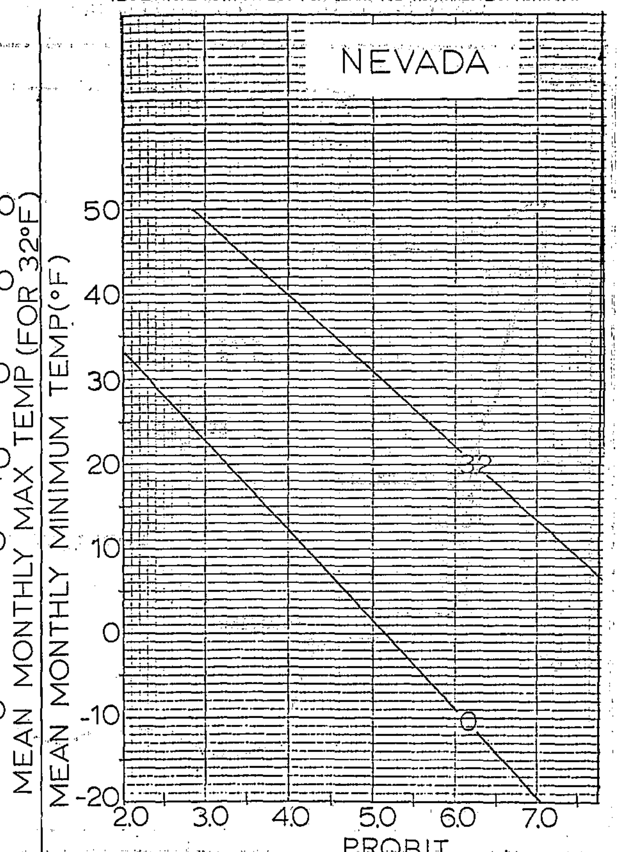

FIGURE 11. REGRESSION LINE RELATING MEAN MONTHLY MINIMUM TEMPERATURE WITH PROBIT FOR NEVADA.

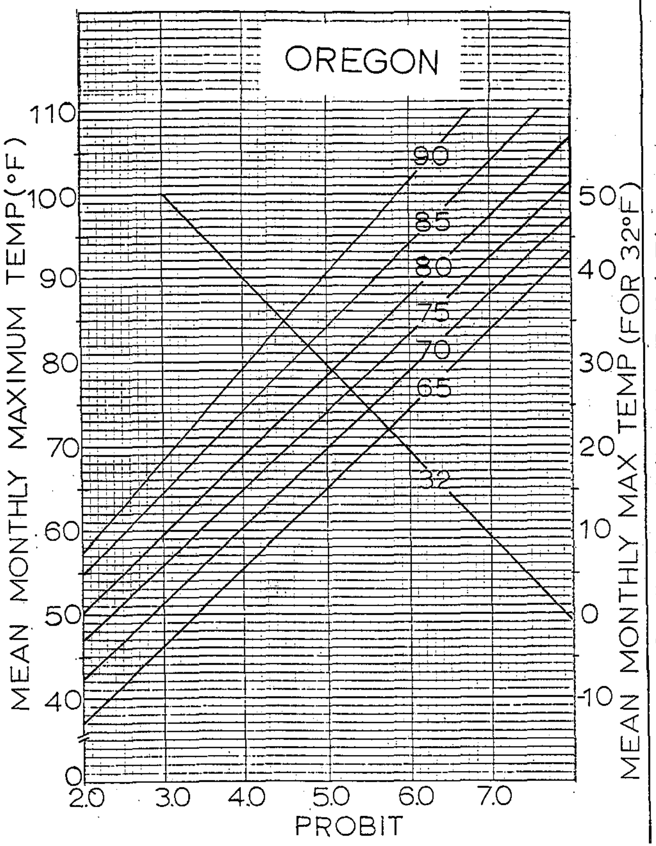

FIGURE 12. REGRESSION LINE RELATING MEAN MONTHLY MAXIMUM TEMPERATURE WITH PROBIT FOR OREGON.

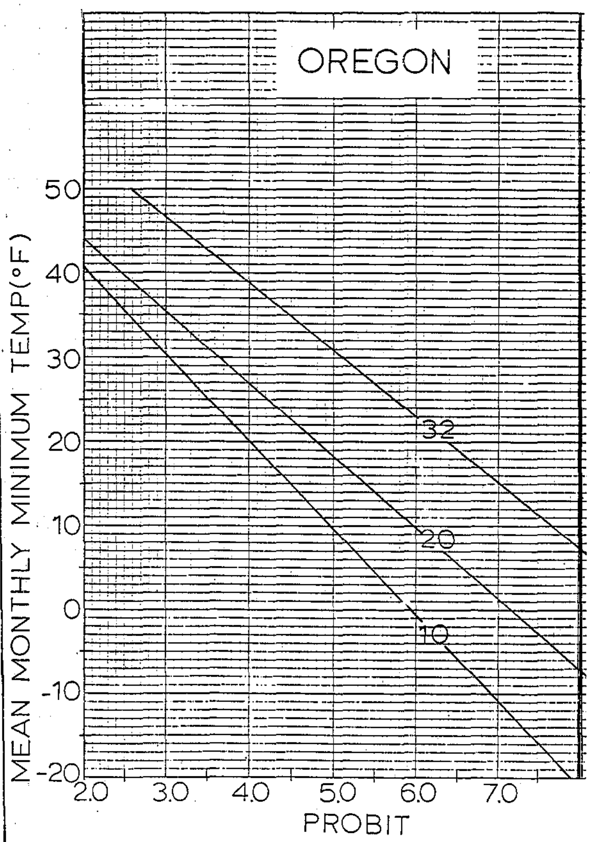

FIGURE 13. REGRESSION LINE RELATING MEAN MONTHLY MINIMUM TEMPERATURE WITH PROBIT FOR OREGON.

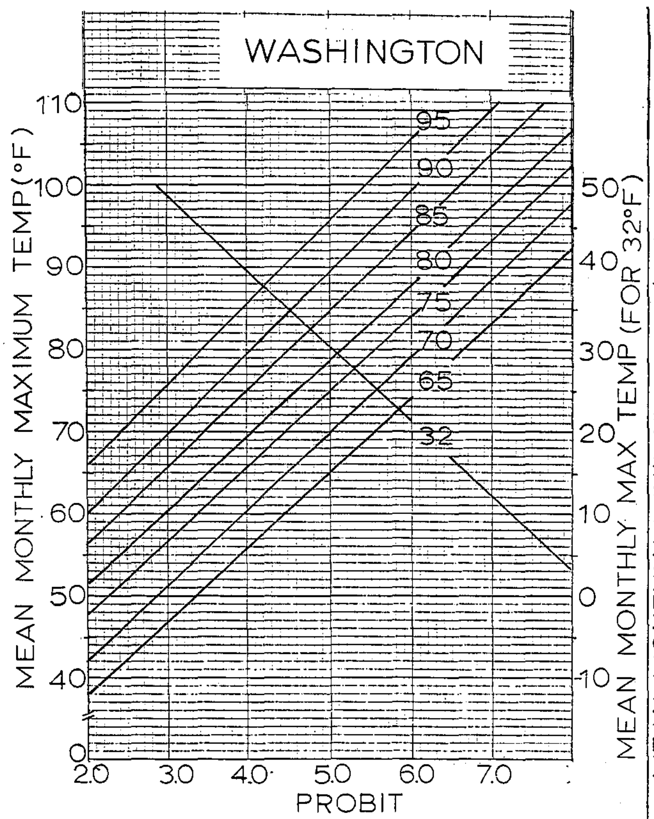

FIGURE 14. REGRESSION LINE RELATING MEAN MONTHLY MAXIMUM TEMPERATURE WITH PROBIT FOR WASHINGTON.

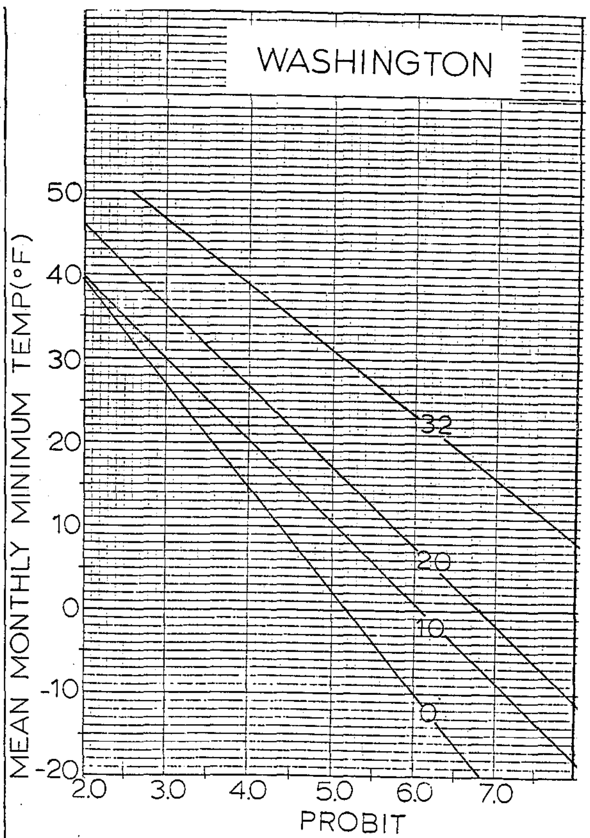

FIGURE 15. REGRESSION LINE RELATING MEAN MONTHLY MINIMUM TEMPERATURE WITH PROBIT FOR WASHINGTON.

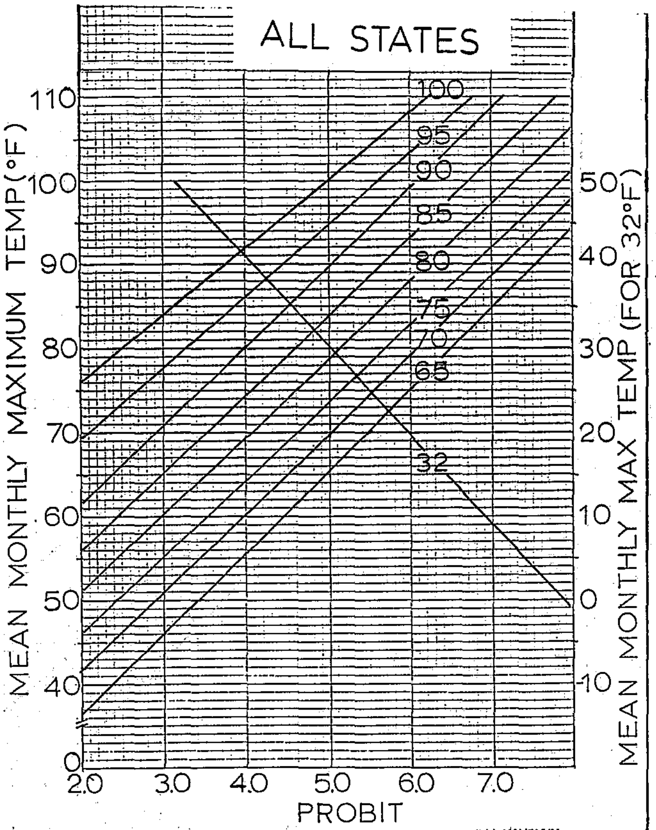

FIGURE 16. REGRESSION LINE RELATING MEAN MONTHLY MAXIMUM TEMPERATURE WITH PROBIT FOR ALL STATES COMBINED.

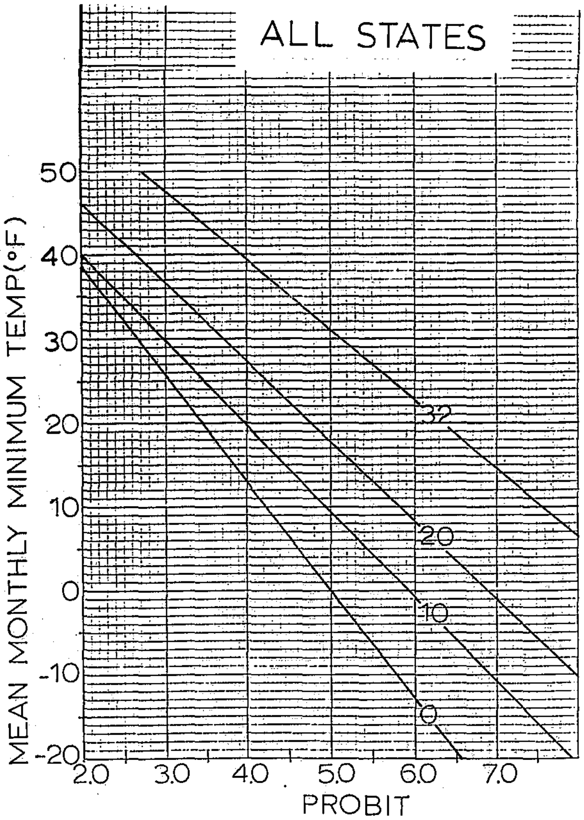

FIGURE 17. REGRESSION LINE RELATING MEAN MONTHLY MINIMUM TEMPERATURE WITH PROBIT FOR ALL STATES COMBINED.

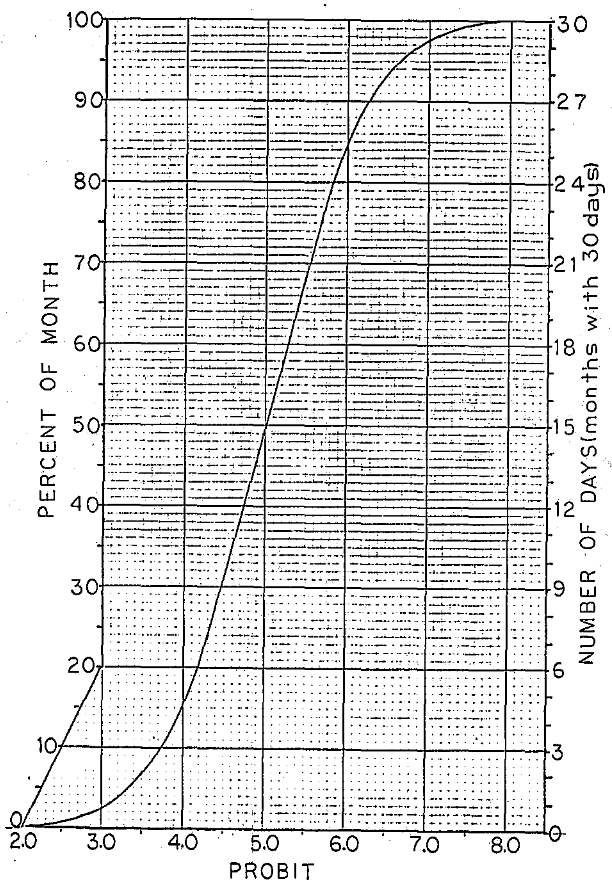

FIGURE 18. GRAPHICAL RELATIONSHIP BETWEEN PROBIT AND PERCENT DAYS OF MONTH AND NUMBER OF DAYS.

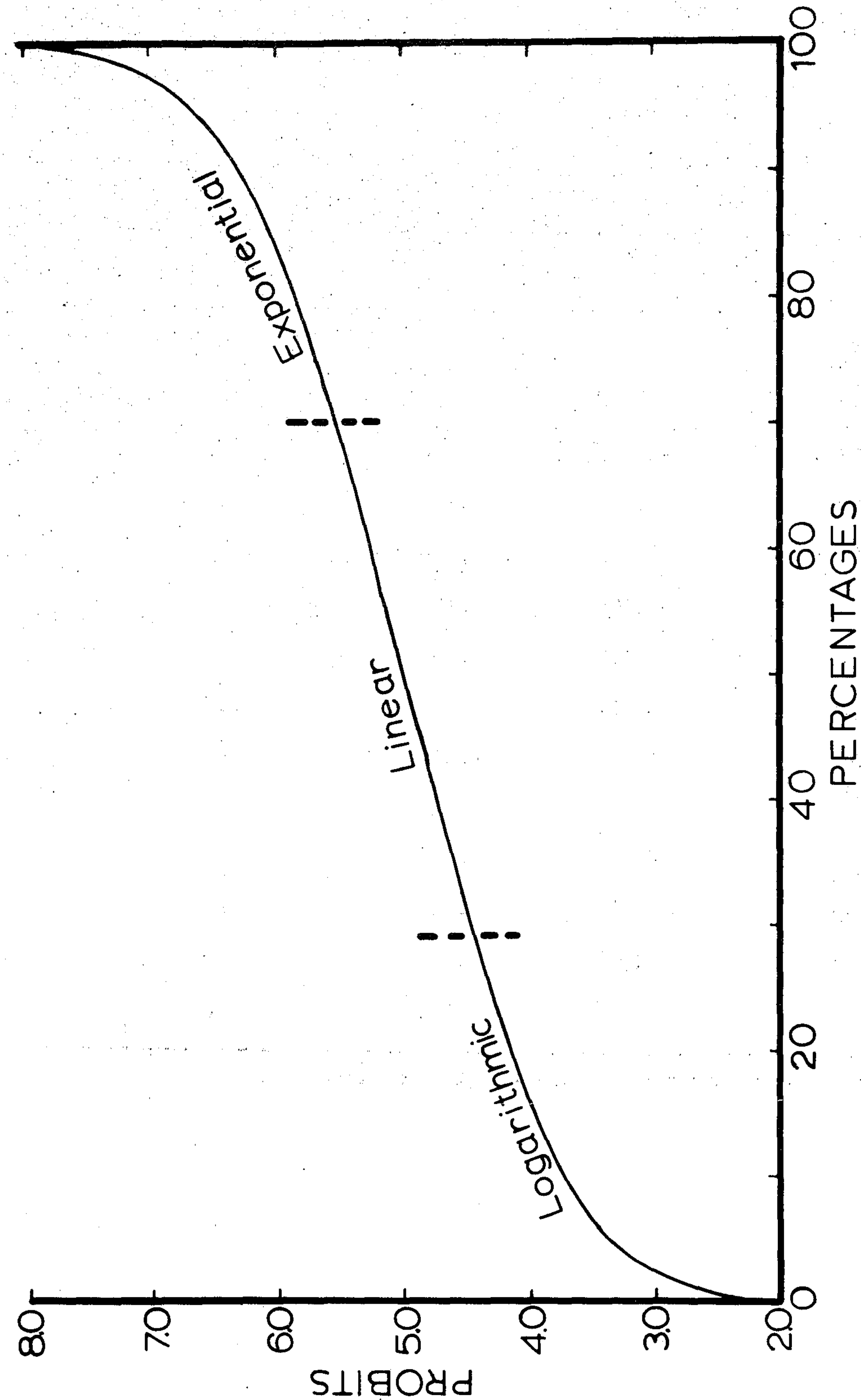

FIGURE 19. RELATIONSHIP BETWEEN PERCENTAGES AND PROBITS.

Table 1 . Summary of Intercept and Regression Coefficients of Probit Transformation for Linear Model, Sample Size and Percent of Variation explained by the Model (R^2) for Estimating the Number of Days above or below selected Temperatures in Idaho-Montana.

TEMPERATURE (F°)		INTERCEPT	REGRESSION COEFFICIENT	SAMPLE SIZE (Months)	R^2
MAX	65	-1.236	.096	130	.984
	70	-1.888	.100	128	.984
	75	-2.777	.106	128	.984
	80	-3.512	.109	115	.986
	85	-4.131	.109	95	.988
	90	-4.295	.103	75	.903
	95	-4.013	.091	46	.812
	100	-0.101	.039	15	.300
	321*	8.024	-.098	93	.951
MIN	32	8.692	-.118	180	.951
	20	6.842	-.104	128	.958
	10	5.928	-.097	96	.962
	0	5.084	-.081	80	.889

*number of days max temperature was 32°F or less

Table 2. Summary of Intercept and Regression Coefficients of Probit Transformation for Linear Model, Sample Size and Percent of Variation explained by the Model (R^2) for Estimating the Number of Days above or below selected Temperatures in Nevada.

TEMPERATURE (F°)		INTERCEPT	REGRESSION COEFFICIENT	SAMPLE SIZE (Months)	R^2
MAX	90	- 6.749	.133	44	.939
	95	- 7.846	.138	51	.970
	100	-11.323	.165	39	.925
	321*	7.163	-.075	34	.817
MIN	32	8.512	-.113	83	.953
	0	5.143	-.094	23	.785

*number of days max temperature was 32°F or less

Table 3. Summary of Intercept and Regression Coefficients of Probit Transformation for Linear Model, Sample Size and Percent of Variation explained by the Model (R^2) for Estimating the Number of Days above or below selected Temperatures in Oregon.

TEMPERATURE (F°)		INTERCEPT	REGRESSION COEFFICIENT	SAMPLE SIZE (Months)	R^2
MAX	65	-1.979	.107	115	.956
	70	-2.526	.108	112	.951
	75	-3.093	.109	98	.958
	80	-3.239	.105	90	.962
	85	-3.420	.100	69	.964
	90	-3.156	.090	56	.887
	95	-2.249	.071	35	.587
	100	-0.543	.046	14	.563
	321*	7.924	-.098	42	.812
MIN	32	8.932	-.127	118	.951
	20	7.160	-.116	63	.951
	10	5.937	-.097	38	.878
	0	4.762	-.065	23	.612

*number of days max temperature was 32°F or less

Table 4. Summary of Intercept and Regression Coefficients of Probit Transformation for Linear Model, Sample Size and Percent of Variation explained by the Model (R^2) for Estimating the Number of Days above or below selected Temperatures in Washington.

TEMPERATURE (F°)		INTERCEPT	REGRESSION COEFFICIENT	SAMPLE SIZE (Months)	R^2
MAX	65	- 2.093	.109	111	.941
	70	- 2.491	.107	105	.964
	75	- 3.184	.109	102	.962
	80	- 3.553	.108	89	.962
	85	- 3.816	.104	72	.941
	90	- 4.116	.102	50	.925
	95	- 4.419	.098	28	.925
	100	-11.507	.172	11	.867
	321*	8.325	-.109	47	.889
MIN	32	8.995	-.127	127	.949
	20	6.819	-.104	65	.935
	10	6.106	-.103	41	.828
	0	5.199	-.080	23	.669

*number of days max temperature was 32°F or less

Table 5 . Summary of Intercept and Regression Coefficients of Probit Transformation for Linear Model, Sample Size and Percent of Variation explained by the Model (R^2) for Estimating the Number of Days above or below selected Temperatures for Combined States.

TEMPERATURE (F°)		INTERCEPT	REGRESSION COEFFICIENT	SAMPLE SIZE (Months)	R^2
MAX	65	-1.704	.103	356	.958
	70	-2.319	.105	345	.962
	75	-3.036	.109	328	.964
	80	-3.495	.108	294	.968
	85	-3.880	.106	236	.956
	90	-4.505	.106	225	.910
	95	-6.153	.118	160	.903
	100	-7.415	.124	79	.821
	321*	7.859	-.095	216	.884
MIN	32	8.749	-.120	508	.951
	20	6.891	-.106	256	.956
	10	5.938	-.097	75	.939
	0	5.011	-.077	149	.806

*number of days max temperature was 32°F or less

Table 6. Independent Data Sites in Five States for Testing Prediction Models.

STATE	SITE	LATITUDE (NORTH)	LONGITUDE (WEST)	ELEVATION (FEET)	NO. YEARS RECORD
IDAHO	Ashton 1S	44° 04'	111° 27'	5220	35
	Avery RS	47° 15'	115° 48'	2492	35
	Grace	42° 35'	111° 44'	5400	35
	Hailey RS	43° 31'	114° 19'	5328	35
	Idaho Falls AP	43° 31'	112° 04'	4730	35
	Oakley	42° 15'	113° 54'	4191	35
	Sandpoint ES	48° 17'	116° 34'	2100	35
MONTANA	Missoula	46° 53'	114° 02'	3172	35
NEVADA	Battle Mountain	40° 39'	116° 56'	4513	30
	Carson City	39° 09'	119° 46'	4651	30
	Desert WL Range	36° 26	115° 22'	2920	30
	Fallon	39° 27'	118° 47'	3965	30
	Lamoille	40° 41'	115° 28'	6290	30
	Lovelock	40° 11'	118° 29'	3977	30
	Mina	38° 23'	118° 06'	4552	30
	Orovada	41° 34'	117° 47'	4310	30
	Pioche	37° 56'	114° 27'	6120	30
OREGON	Forest Grove	45° 32'	123° 06'	175	35
	Grants Pass	42° 26'	123° 19'	925	35
	Heppner	45° 21'	119° 33'	1950	35
	Madras 2N	44° 40'	121° 09'	2500	35
	Moro ES	45° 29'	120° 43'	1858	35
	Parkdale	45° 35'	121° 30'	1740	35
	Pendleton	45° 41'	118° 51'	1489	35
	Prineville 2NW	44° 19'	120° 52'	2868	35
	Prospect 2SW	42° 44'	122° 31'	2482	35
	Union	45° 13'	117° 05'	2765	35
	Warm Springs R	43° 35'	118° 13'	3352	35
WASHINGTON	Concrete	48° 32'	121° 45'	270	35
	Goldendale	45° 49'	120° 50'	1635	35
	Kosmos	46° 30'	122° 39'	775	33
	Landsburg	47° 23'	121° 58'	535	32
	Palmer 3SE	47° 18'	121° 50'	895	35
	Rainier Longmire	46° 45'	121° 49'	2762	27
	Snoqualmie Falls	47° 33'	121° 51'	440	35
	Vancouver	45° 38'	122° 41'	100	35
	Walla Walla 3W	46° 03'	118° 24'	800	32
	Wenatchee	47° 25'	120° 19'	634	35
	Wilbur	47° 45'	118° 42'	2163	35
	Wind River	45° 48'	121° 56'	1145	35
	Winthrop 1WSW	48° 28'	120° 11'	1755	36

Table 7. Correlation Coefficient (R) and Sample Size (Months) of Observed Versus Computed Percent Days Above or Below Selected Temperatures on Independent Samples for Combined Model and Individual State Model.

TEMPERATURE	COMBINED STATES		IDAHO-MONTANA		OREGON		NEVADA		WASHINGTON	
	R	MONTHS	R	MONTHS	R	MONTHS	R	MONTHS	R	MONTHS
MAX										
65	.984	236	.989	54	.992	83	--	--	.978	99
70	.988	235	.986	56	.993	85	--	--	.985	94
75	.988	225	.986	54	.994	80	--	--	.987	91
80	.963	20	.988	40	.937	78	--	--	.982	86
85	.959	162	.981	34	.990	62	--	--	.923	66
90	.954	177	.947	23	.973	53	.955	50	.953	51
95	.856	70	.790	12	.892	34	--	--	.952	24
100	.712	26	--	2	.742	15	--	--	.787	9
32	.902	46	.948	40	.892	32	.694	30	.915	44
MIN										
32	.961	363	.945	74	.977	103	.969	89	.967	97
20	.940	170	.910	53	.955	62	--	--	.940	55
10	.882	103	.845	39	.842	34	--	--	.829	30
0	.765	85	.787	35	.626	19	.469	17	.882	14

Table 8. Variables for 95 Percent Confidence Interval[a/] on the Predicted Value (Probit Transformation of the Percent of Days Above or Below Selected Temperatures) from Individual Monthly Mean Maximum or Mean Minimum Temperatures for Idaho-Montana.

TEMPERATURE		$t_{.05}$ (n-2 df)	STANDARD DEVIATION ($s_{y.x}$)	SAMPLE SIZE (n)	MEAN ($\bar{x}$)	Σx^2 *
MAX	65	1.980	.139	130	66.4	16358.5
	70	1.980	.131	128	70.9	12958.8
	75	1.980	.141	128	72.6	12426.2
	80	1.981	.120	115	74.9	9265.7
	85	1.998	.149	95	77.6	5118.6
	90	1.996	.213	75	80.1	2829.9
	95	2.016	.202	46	83.6	932.5
	100	2.160	.207	15	87.8	155.4
	32	1.990	.138	93	38.3	3409.3
MIN	32	1.980	.261	180	29.1	16662.3
	20	1.980	.168	128	21.3	7431.9
	10	1.989	.119	96	18.2	3544.3
	0	1.994	.159	80	16.7	2395.7

a/ 95% C.I. = $\bar{y} + bx \pm t_{.05}\, s_{y.x} \sqrt{1 + \frac{1}{n} + \frac{x^2}{\Sigma x^2}}$ where $x = X - \bar{x}$; $\bar{x}$ is the mean and X the observed data.

* Corrected sum of squares

Table 9. Variables for 95 Percent Confidence Interval on the Predicted Value[a/] (Probit Transformation of the Percent of Days Above or Below Selected Temperatures) from Individual Monthly Mean Maximum or Mean Minimum Temperatures for Nevada.

TEMPERATURE		$t_{.05}$ (n-2 df)	STANDARD DEVIATION ($s_{y.x}$)	SAMPLE SIZE (n)	MEAN ($\bar{x}$)	Σx^2 *
MAX	90	2.016	.245	44	85.4	2210.5
	95	2.011	.181	51	90.9	2795.2
	100	2.036	.283	39	94.5	1365.2
	32	2.037	.191	34	44.8	925.7
MIN	32	1.992	.263	83	30.4	8873.4
	0	2.080	.202	23	17.4	356.5

a/ 95% C.I. = $\bar{y} + bx \pm t_{.05}\, s_{y.x} \sqrt{1 + \frac{1}{n} + \frac{x^2}{\Sigma x^2}}$ where $x = X - \bar{x}$; $\bar{x}$ is the mean and X the observed data.

* Corrected sum of squares

Table 10. Variables for 95 Percent Confidence Interval[a] on the Predicted Value (Probit Transformation of the Percent of Days Above or Below Selected Temperatures) from Individual Monthly Mean Maximum or Mean Minimum Temperatures for Oregon.

TEMPERATURE		$t_{.05}$ (n-2 df)	STANDARD DEVIATION ($s_{y.x}$)	SAMPLE SIZE (n)	MEAN ($\bar{x}$)	Σx^2 *
MAX	65	1.982	.234	115	64.2	11770.3
	70	1.983	.251	112	68.2	11474.2
	75	1.988	.214	98	71.9	8433.3
	80	1.991	.184	90	73.1	6839.1
	85	1.998	.145	69	76.3	3771.5
	90	2.004	.204	56	78.5	2197.9
	95	2.031	.281	35	82.2	2875.5
	100	2.179	.197	14	84.9	284.1
	32	2.020	.221	42	42.8	883.8
MIN	32	1.981	.238	118	32.4	7845.0
	20	1.999	.164	63	26.5	2330.6
	10	2.025	.169	38	22.6	782.1
	0	2.080	.197	23	20.0	302.3

a/ 95% C.I. = $\bar{y} + bx \pm t_{.05}\, s_{y.x} \sqrt{1 + \frac{1}{n} + \frac{x^2}{\Sigma x^2}}$ where $x = X - \bar{x}$; $\bar{x}$ is the mean and X the observed data.

* Corrected sum of squares

Table 11. Variables for 95 Percent Confidence Interval[a/] on the Predicted Value (Probit Transformation of the Percent of Days Above or Below Selected Temperatures) from Individual Monthly Mean Maximum or Mean Minimum Temperatures for Washington.

TEMPERATURE		$t_{.05}$ (n-2 df)	STANDARD DEVIATION ($s_{y.x}$)	SAMPLE SIZE (n)	MEAN ($\bar{x}$)	Σx^2 *
MAX	65	1.983	.263	111	66.1	10025.4
	70	1.985	.183	105	68.4	8084.6
	75	1.995	.191	102	70.8	8004.1
	80	1.990	.174	89	72.6	5671.5
	85	1.996	.189	72	74.8	3652.8
	90	2.013	.180	50	77.9	1857.9
	95	2.056	.142	28	82.0	669.9
	100	2.262	.106	11	87.6	22.6
	32	2.014	.187	47	40.0	1063.4
MIN	32	1.980	.223	127	33.1	7158.1
	20	1.999	.147	65	27.2	1808.6
	10	2.025	.187	41	24.0	618.9
	0	2.080	.186	23	21.6	228.7

a/ 95% C.I. = $\bar{y} + bx \pm t_{.05}\, s_{y.x} \sqrt{1 + \frac{1}{n} + \frac{x^2}{\Sigma x^2}}$ where $x = X - \bar{x}$; $\bar{x}$ is the mean and X the observed data.

* Corrected sum of squares

Table 12. Variables for 95 Percent Confidence Interval on the Predicted Value[a/] (Probit Transformation of the Percent of Days Above or Below Selected Temperatures) from Individual Monthly Mean Maximum or Mean Minimum Temperatures for Combined States.

TEMPERATURE		$t_{.05}$ (n-2 df)	STANDARD DEVIATION ($s_{y.x}$)	SAMPLE SIZE (n)	MEAN ($\bar{x}$)	Σx^2 *
MAX	65	1.960	.223	356	65.6	38470.2
	70	1.960	.202	345	69.2	33085.4
	75	1.960	.195	328	71.8	29063.5
	80	1.960	.170	294	73.6	22086.3
	85	1.960	.167	236	73.4	12866.9
	90	1.960	.233	225	80.2	10689.9
	95	1.970	.268	160	85.3	7545.6
	100	1.993	.368	79	90.6	3097.4
	32	1.960	.205	216	40.6	7595.5
MIN	32	1.960	.252	508	31.1	42016.4
	20	1.960	.164	256	24.1	13509.9
	10	1.960	.147	175	20.5	6110.7
	0	1.970	.193	149	18.1	3805.8

a/ 95% C.I. = $\bar{y} + bx \pm t_{.05}\, s_{y.x} \sqrt{1 + \frac{1}{n} + \frac{x^2}{\Sigma x^2}}$ where $x = X - \bar{x}$; $\bar{x}$ is the mean and X the observed data.

* Corrected sum of squares

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