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A COMPARISON OF CONDITIONAL AND UNCONDITIONAL FORECASTS OF THE PROBABILITY OF PRECIPITATION AMOUNT

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1. INTRODUCTION

A system for forecasting the probability of precipitation amount (PoPA) and categorical forecasts of precipitation amount has been operational since February 1975 (Bermowitz and Zurndorfer, 1979). Forecasts are made twice daily for the categories $\geq .25$, $\geq .50$, ≥ 1.0, and ≥ 2.0 inches for various projections from 0000 GMT and 1200 GMT.

Until now, the PoPA system has been an unconditional system; that is, we use both rain and no rain cases in our developmental sample. Note that for a given period, a rain case is defined as getting $\geq .01$ inch of precipitation in that period. This unconditional PoPA system came about as the result of testing by Bermowitz (1975), who showed that the unconditional PoPA forecasts were about as good as the conditional PoPA forecasts. However, in developing PoPA equations for testing the two systems, Bermowitz (1975) had only 2 years of developmental data. Consequently, the developmental data had to be pooled and generalized operator equations for both systems were derived and tested.

Recently, the question has arisen once again as to whether we should make our PoPA system a conditional system. This is the result of the use of many more years of developmental data and the existence of a regionalized PoPA system (Bermowitz and Zurndorfer, 1979). In this paper, we describe some experiments we performed to compare the unconditional and conditional PoPA.

2. DEVELOPMENT

We first developed unconditional PoPA equations using the Regression Estimation of Event Probabilities (REEP) technique (Miller, 1964). In the REEP technique, the predictand takes on the value 1 if the event occurs and 0 if the event does not occur. For example, suppose that for a given projection at a given station .74 inch of precipitation occurred. Then the predictands $\geq .25$ and $\geq .50$ inches are assigned the value 1 while the predictands ≥ 1.0 and ≥ 2.0 inches are assigned the value 0 for that observation. Note again that in the unconditional system both rain ($\geq .01$ inch) and no rain ($< .01$ inch) cases are used in the equation development.

Next, we developed conditional PoPA equations. Here we included only rain cases in our developmental sample. In the statistical development, the predictand, say $\geq .25$ inch, is assigned the value 1 if $\geq .25$ inch of precipitation occurred and 0 if $\geq .01$ and $< .25$ inch of precipitation occur in that period. That is, we estimate, for example, the probability of

$\geq$.25 inch in any period given that precipitation has occurred in that period = $P(\geq.25|\geq.01)$. By definition of conditional probability (see, for example, Hogg and Craig, 1970),

$$P(\geq.25|\geq.01) = \frac{P(\geq.25)}{P(\geq.01)} \tag{1}$$

or

$$P(\geq.25) = P(\geq.01)\ P(\geq.25|\geq.01) \tag{2}$$

Therefore, in order to convert the conditional PoPA forecast at a given station to an unconditional PoPA forecast at that station, we simply multiply the conditional PoPA times the probability of precipitation (PoP) for that station. This multiplication is performed for all the predictands developed conditionally and is needed in order to directly compare the conditional PoPA with the unconditional PoPA. The PoP forecasts are also obtained from equations derived using the MOS technique (Glahn and Lowry, 1972). Three sets of 0000 GMT cycle forecasts were evaluated; 12-24 h warm season (April-September) forecasts based on the Limited-area Fine Mesh (LFM) (Gerrity, 1977) model, 24-48 h cool season (October-March) forecasts for the Columbia River Basin (Bermowitz et al., 1977) based on the Primitive Equation (PE) (Shuman and Hovermale, 1968) model, and 12-18 h cool season forecasts based on the LFM model. The choice of these sets of forecasts represents an attempt to select independent data with as much variety as possible. Each independent data set consisted of 1 year of data.

The stations and regions used to develop equation sets (1), (2), and (3) above are shown in Figs. 1, 2, and 3 respectively. Equations for the categories $\geq$.25, $\geq$.50, $\geq$1.00, and $\geq$2.00 inches were developed for the 12- and 24-h projection while for the 6-h projection, equations were developed for $\geq$.25, $\geq$.50, and $\geq$1.00 inches since the occurrence of $\geq$2.00 inches is relatively rare in a 6-h period.

3. RESULTS AND CONCLUSIONS

The results of the comparative verification are shown in Tables 1 through 3. In each case, we used the Brier P-score (Brier, 1950) as our verification statistic.

From these tables it is apparent that the conditional PoPA system is slightly better than the unconditional PoPA system. It appears from the Tables 2 and 3 that the conditional PoPA system performs better relative to the unconditional PoPA system in the cool season than in the warm season. Also, the conditional PoPA system performed better in the Columbia River Basin than did the unconditional system.

By region, we noticed (results not shown) that the conditional PoPA system had somewhat better results in drier regions, such as regions 6, 7, and 8 in Fig. 1, regions 4 and 5 in Fig. 2, and regions 6 and 7 in Fig. 3. This could be partially due to the fact that the relative frequencies of occurrence for the events $\geq .25$, $\geq .50$, ≥ 1.00, and ≥ 2.00 inches are small in dry regions in the unconditional system. In the conditional system, these relative frequencies are larger. Consequently, the reductions of variance (which are closely related to the relative frequencies) increase to a greater extent in the conditional system relative to the unconditional system in drier regions than in wetter regions.

4. OPERATIONAL ASPECTS

An important aspect of the PoPA system to consider here is that of the conversion of probability forecasts to categorical forecasts of precipitation amount. Recently, a new technique was implemented in our operational programs to determine threshold probabilities for converting probability forecasts to categorical forecasts (Bermowitz and Best, 1979). This technique can only be used operationally in the unconditional PoPA system. For the conditional PoPA system, we must first convert the conditional PoPA forecasts to unconditional PoPA forecasts on the dependent data and then use an iterative technique to determine threshold probabilities. This iterative technique requires more computer time and, indeed, is not justified in view of the only slight decrease in P-scores of the conditional PoPA forecasts over the unconditional PoPA forecasts.

Therefore, we will retain our current unconditional PoPA system. These forecasts will continue to be available on the FOUS12 bulletin, which is available on request/reply for both the 0000 and 1200 GMT model cycles (Bermowitz and Zurndorfer, 1979).

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Table 1. Average P-scores for approximately 230 stations shown in Fig. 1 for the 12-24 h warm season LFM-based PoPA equations. The P-scores were computed on the independent data sample, warm season 1978 (180 days).

Category (inch)	PoPA System	
	Conditional	Unconditional
$\geq .25$	.09337	.09363
$\geq .50$	.05223	.05248
≥ 1.00	.01802	.01808
≥ 2.00	.00468	.00468

Table 2. Average P-scores for approximately 87 stations shown in Fig. 2 for the 24-48 h cool season PE-based PoPA equations. The P-scores were computed on the independent data sample, cool season 1977-78 (177 days).

Category (inch)	PoPA System	
	Conditional	Unconditional
$\geq .25$	.18234	.18804
$\geq .50$	.10274	.10589
≥ 1.00	.04511	.04646
≥ 2.00	.02654	.02691

Table 3. Average P-scores for approximately 230 stations shown in Fig. 3 for the 12-18 h cool season LFM-based PoPA equations. The P-scores were computed on the independent data sample, cool season 1978-79 (175 days).

Category (inch)	PoPA System	
	Conditional	Unconditional
$\geq .25$	.03755	.03805
$\geq .50$	.01537	.01547
≥ 1.00	.00489	.00493

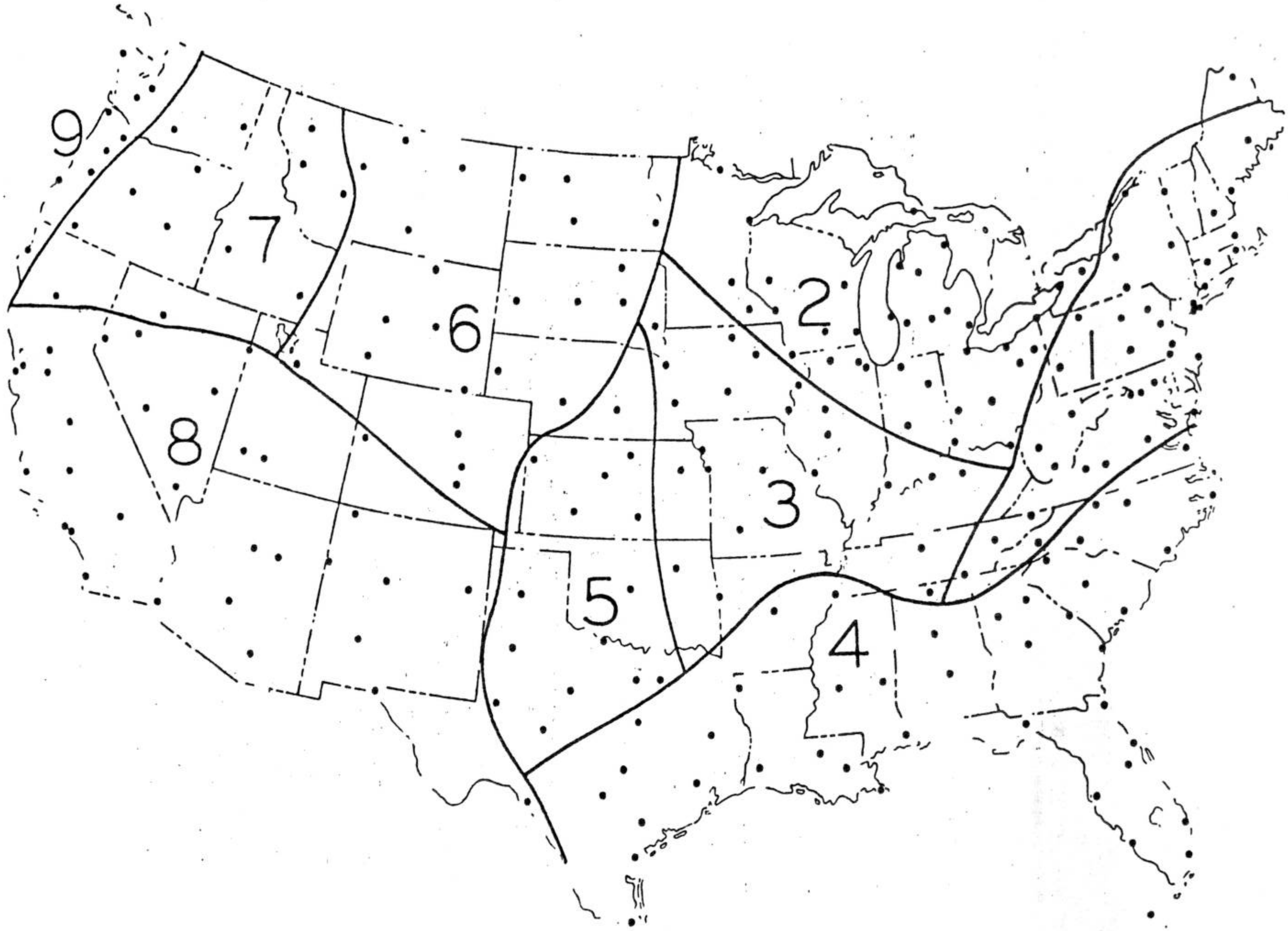

Figure 1. The nine regions used to develop the early guidance 12-24 h warm season equations.

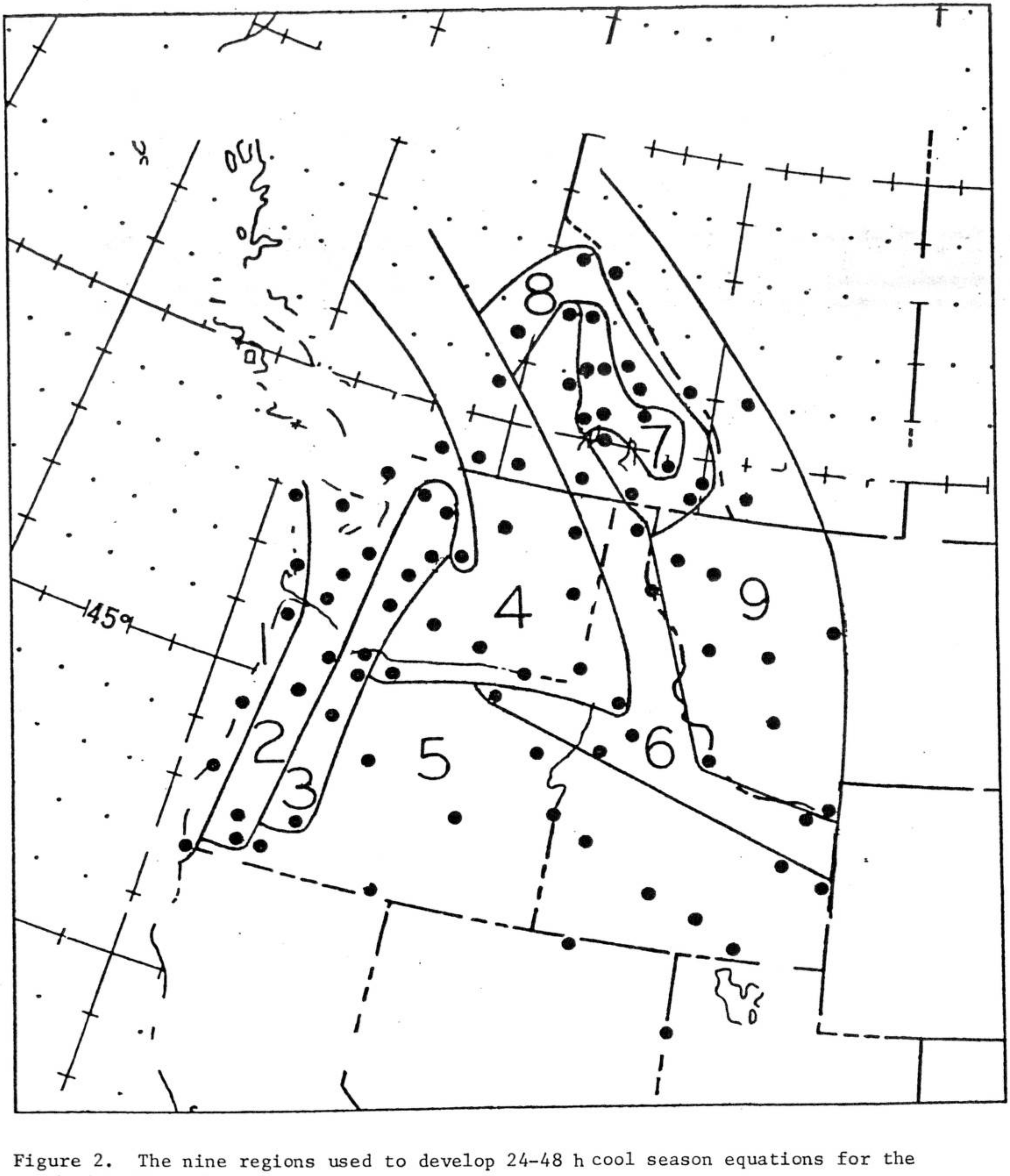

Figure 2. The nine regions used to develop 24-48 h cool season equations for the Columbia River Basin.

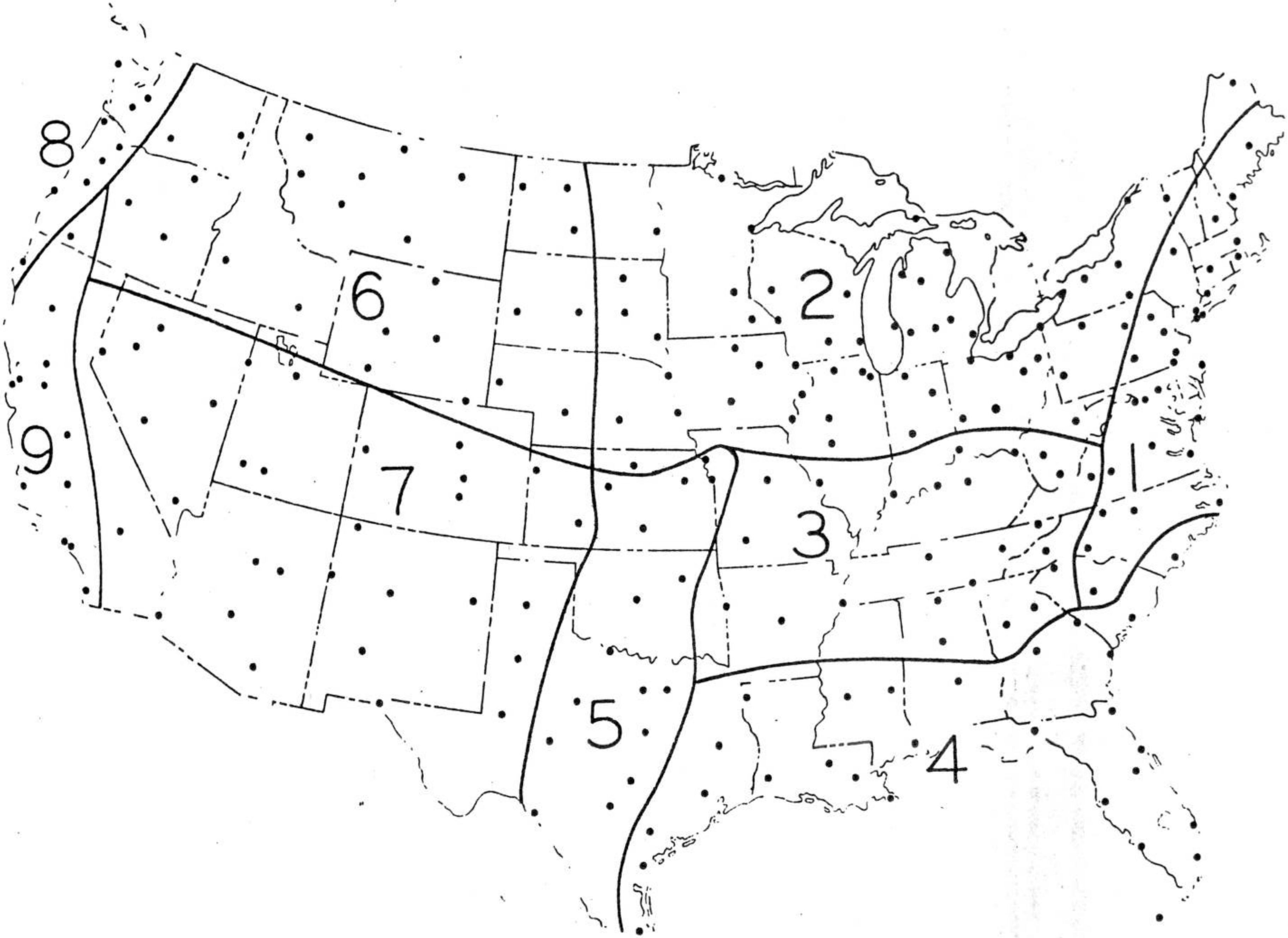

Figure 3. The nine regions used to develop the early guidance 12-18 h cool season equations.