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THE USEFULNESS OF DATA FROM MOUNTAINTOP FIRE LOOKOUT STATIONS IN DETERMINING ATMOSPHERIC STABILITY

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I. INTRODUCTION

As an aid in fire season (June-October) thunderstorm forecasting, the Redding Fire Weather Office has been using a lifted index derived from data taken at several mountaintop fire lookout stations in northern California. This technique is simple to use and has proven to be very useful. The purpose of this paper is to share the technique with other areas that have the necessary terrain but that may not have been taking advantage of it.

II. DISCUSSION

Stability indexes in general are only part of what needs to be considered in thunderstorm forecasting. Their usefulness can be further limited by differences in time, location, and terrain between the area of interest and that of the RAOB. As an example, in the Redding Fire Weather District, stabilities derived from RAOBs taken at Medford and Oakland are of limited use, since intrusions of moist air often reach portions of our district without getting to either RAOB site. When this happens, the RAOBs may give the stability of an air mass quite different from the one affecting our district. Thus, a more detailed look at the stability picture can be very helpful.

One way to obtain this increased detail is to use data from mountaintop fire lookout stations (Mihelic 1958); many of which take weather observations used in helping to determine fire danger. Unlike data from lower elevations or even high valleys, the wet-bulb temperature of the mountaintop stations can usually be assumed to be representative of the free air moisture content of the atmosphere in the lower levels. It can, therefore, be used to derive a stability index as explained below. There can be problems with this assumption. For example, in the Redding district moisture air intrusions from the Pacific through a long valley leading through the coast range can result in unrepresentative readings from the Limedyke Lookout (see location on Figure 3). However, once potential problems such as this have been identified, they can be spotted fairly easily.

A lifted index can be derived from this moisture data and the upper-air temperature (500-mb) interpolated between the normal RAOB network. This is made easier when the lookout reports its wet-bulb temperature, as is usually the case, since the wet-bulb temperature defines the same moist adiabat intersecting the level of the reporting station that would have been arrived at using the station temperature and dew point and lifting it to saturation. This moist adiabat can be followed to the 500-mb level and compared with the 500-mb temperature interpolated between the normal RAOB network giving an index of stability (Figure 1). We have constructed a nomogram to simplify these computations in Redding (Figure 2). The heights of the lookout stations are determined by locating their altitudes in the standard atmosphere. The lookouts used in the Redding district are mostly located between 4500 and

8000 feet. The stabilities produced by this method have a range of values similar to those of standard lifted indexes.

Currently at the Redding Fire Weather Office, we use the data from lookout reports taken at 0700 local time. These are used to check the accuracy of the previous afternoon forecast, which is updated in the morning, and to provide a starting point for the forecast valid the next day.

III. PROCEDURES

To determine the usefulness of the scheme, hourly radar summaries from most of the summer seasons of 1976 and 1977 (August 1977 was not available) were examined for the amount and distribution of thunderstorm activity. A comparison was made between the potential for thunderstorms as determined from the Medford and Oakland soundings (K value and Showalter Index), and that indicated by the lookout data, to see which fit the observed activity best. The main emphasis was on how well changes in the indexes indicated changes in the amount and location of thunderstorm activity.

The emphasis was put on the trends of the stability values. This was to be more useful to the forecaster in indicating daily changes in thunderstorm activity than the use of specific yes or no values, or of trying to correlate certain ranges of stability values with ranges of thunderstorm probability. Thus, some values would usually be considered so unstable as to indicate a likelihood of thunderstorms, even if they showed a trend toward more stability. Others would be too stable for any activity even if they showed a trend to lower stability. But a wide range of values would obtain significance primarily from the values leading to them.

Also included for comparison was an objective technique by Oertel. This technique gives the probability of thunderstorms anywhere in the Redding district from a combination of results derived by using the mean winds over the district at 500-mb, as well as the Showalter Indexes from Medford and Oakland. The inclusion of the upper-level wind flow is significant since thunderstorm activity in northern California is highly dependent on the direction and strength of this flow (Hansen 1965, Oertel).

To determine how useful the lookout stabilities are as an aid in thunderstorm forecasting for small areas, the Redding district was divided into five sections (Figure 3). Thunderstorm activity in the Sacramento valley was not investigated since the lookouts are primarily located in, and their data are used for, the surrounding forests. The reports from Baldy Mountain and Limedyke were used for the southwest, Happy Camp and Burney Mountain for the northeast, and Dyer Mountain and Smith Peak were the primary lookouts used for the southeast. Inskip Hill and Burney Mountain were used to establish a trend in the southeast, if the primary stations had opposing trends.

The data from Medford and Oakland as well as the objective study and a combination of all the lookout reports were compared with changes in activity in the district as a whole. Days with significantly observed changes in thunderstorm activity were noted and the effectiveness of the different indexes in showing these changes was evaluated. Tables I and II show the results of this. If a change was correctly indicated by a particular index, the case was added to its "correct" list. If the index went the wrong way, an "incorrect" was given. If the index did not indicate a change, its range of value was clearly outside the appropriate range or a mixed indication was shown, a "no trend indicated" was given. For example, if an increase in activity occurred and the indexes for an area actually showed less stability than the day before, but even at the lower value would have to be considered too stable for thunderstorm activity, then the change in activity was not considered to have been properly represented and a "no trend indicated" was given.

Also examined were days when there was no or only very little change in observed activity. The indexes were examined to see if this would have been expected if a forecast had been based upon them. Table III gives the results of this. Cases were totaled where a false change one way or the other was indicated. If opposing trends were forecast by the two stations in an area, no trend was considered to have been shown and the case was not counted as a false indication. The various indexes were also not considered to have given a false indication of change in cases where they occurred on either day, or when a decrease in stability, was shown but heavy activity was already occurring.

Cases in which the thunderstorm activity developed overnight were difficult to fit into this scheme and a few were not included in this study.

IV. RESULTS

An examination of the results shows that the lifted indexes derived from the lookout stations often did a better job and were never significantly worse than any of the examined indexes based on the Medford and Oakland soundings or our local objective method.

In the "observed increase" cases (Table I), both the increases in northern California as a whole as indicated by the general trend of the lookout indexes and the increase in specific areas as shown by the appropriate lookout indexes clearly did better than any of the other methods.

The lookout indexes improvement over other methods was not as great in the "observed decrease" cases (Table II). The two types of lookout derived indexes remained at approximately 50% correct, but there was an improvement to or near the same level by a few of the other indexes.

In the "false-start" category (Table III), where an index indicated a change that did not occur, the results were fairly close. The poorest performance would seem to have been that of the specific areas as compared to the district as a whole. However, it should be remembered that these forecasts are for areas about 1/5 the size of the Redding district but still resulted in similar accuracy to the other methods used for the district as a whole. Also many of these false indications occurred in one steadily identified and repeated situation, discussed below. Thus, the lookout station method generates useful information as to the specific location of the thunderstorm activity that would not be available from the general area methods.

Many of the failures of the stability indexes were due to rapid changes occurring after the time of observation. The stabilities usually showed a trend toward lower stability on the day after an increase in thunderstorm activity that had not been indicated. This happened whether or not there was any further increase in activity and even when there was a decrease. This situation accounted for many of the false indications of increased activity shown in Table III. The specific area lookout indexes were disproportionately affected by this since the moisture intrusions (usually from the south or southeast) resulting in the thunderstorms frequently reaching some and occasionally all of the forest areas where the lookouts are located without making it to Oakland or Medford. In these cases the Medford and Oakland stabilities usually indicated no change on either day.

Intrusions of moisture from the south often produce lower stability readings on both sides of the Sacramento valley in the southern portion of our district. Since different upper-level wind flows favor thunderstorm development on different sides of the valley, adding wind flow information to the stability data can help the forecaster in determining which of the stability readings is giving him the best indication of thunderstorm activity.

V. CONCLUSIONS

A representative "lifted index" of atmospheric stability can be determined using normal RAOB data for the 500-mb temperature and data from morning mountaintop fire lookout stations for the low-level temperature and moisture data as described. Thus, a much more detailed analysis of atmospheric stability than would be available from only RAOB station data can easily be derived. This method has proved to be very useful in summer thunderstorm forecasting in the Redding Fire Weather District and should prove equally helpful in other areas with varying terrain. Also, if communications do not pose a great problem, it would be fairly simple matter to produce a detailed stability analysis of the entire mountainous West for distribution via RAFAX or AFOS.

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TABLE I

DAYS WITH AN OBSERVED INCREASE IN THUNDERSTORM ACTIVITY

STABILITY INDEX		CASES	CORRECT TREND	INCORRECT TREND	NO TREND INDICATED
SHOWALTER	MFR	23	7 (30%)	7 (30%)	9 (39%)
	OAK	25	3 (12%)	3 (12%)	19 (76%)
K VALUE	MFR	21	8 (38%)	5 (24%)	8 (38%)
	OAK	21	3 (14%)	2 (10%)	16 (76%)
LOCAL OBJECTIVE STUDY		19	6 (32%)	5 (26%)	8 (42%)
LOOKOUT DATA	SPECIFIC AREAS	56	25 (45%)	10 (18%)	21 (37%)
	GENERAL AREA	24	12 (50%)	2 (8%)	10 (42%)

TABLE II

DAYS WITH AN OBSERVED DECREASE IN THUNDERSTORM ACTIVITY

STABILITY INDEX		CASES	CORRECT TREND	INCORRECT TREND	NO TREND INDICATED
SHOWALTER	MFR	23	10 (43%)	5 (22%)	8 (35%)
	OAK	22	11 (50%)	4 (18%)	7 (32%)
K VALUE	MFR	23	9 (39%)	7 (30%)	7 (30%)
	OAK	22	8 (36%)	4 (18%)	10 (45%)
LOCAL OBJECTIVE STUDY		23	10 (43%)	4 (17%)	9 (39%)
LOOKOUT DATA	SPECIFIC AREAS	53	26 (49%)	8 (15%)	19 (36%)
	GENERAL AREA	23	12 (52%)	7 (30%)	4 (17%)

TABLE III

NO OBSERVED CHANGES IN THUNDERSTORM ACTIVITY

STABILITY INDEX		CASES	INDICATED INCREASE	INDICATED DECREASE
SHOWALTER	MFR	43	4 (9%)	0
	OAK	41	4 (10%)	0
K VALUE	MFR	43	6 (14%)	1 (2%)
	OAK	41	0	1 (2%)
LOCAL OBJECTIVE STUDY		38	5 (13%)	1 (3%)
LOOKOUT DATA	SPECIFIC AREAS	109	30 (28%)	4 (4%)
	GENERAL AREA	43	3 (7%)	0

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CHART WEA D-11

PSEUDO-ADIABATIC CHART

LOWER LEVELS

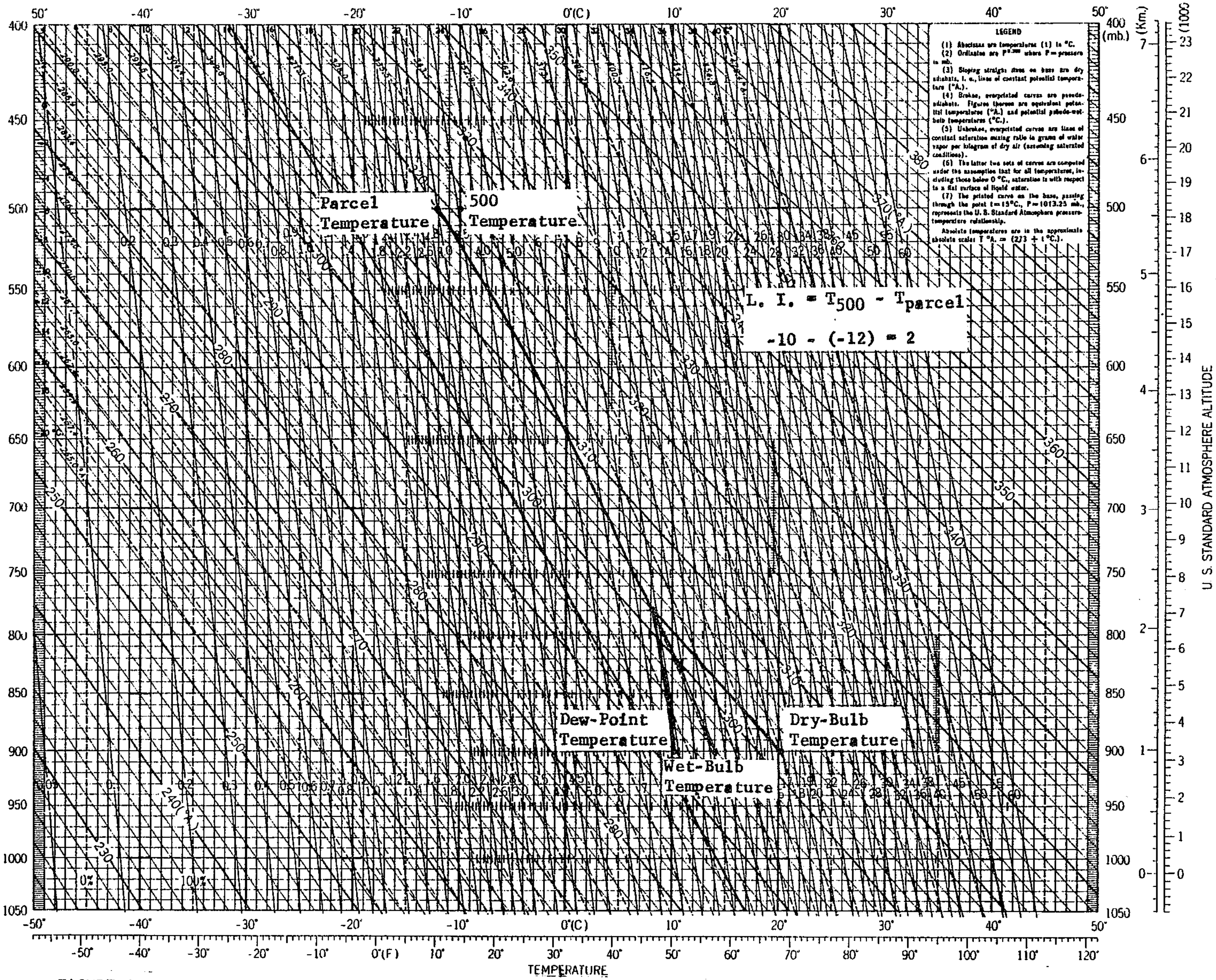

FIGURE 1. PSEUDO-ADIABATIC CHART DEPICTING THE RELATIONSHIP BETWEEN DEW-POINT TEMPERATURE, WET-BULB TEMPERATURE, AND DRY-BULB TEMPERATURE FOR A LIFTED AIR PARCEL.

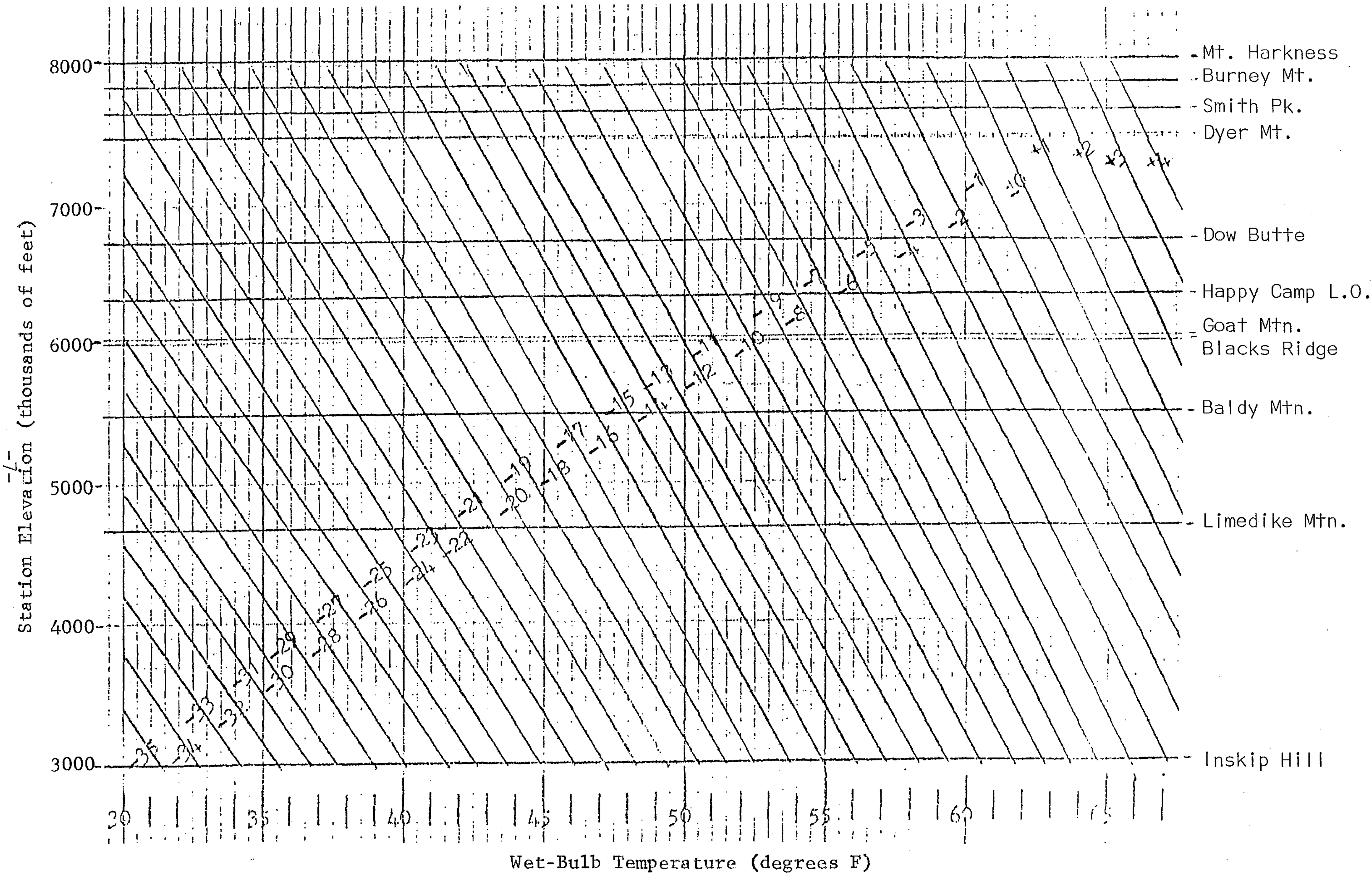

FIGURE 2. STABILITY INDEX COMPUTATION NOMOGRAM FOR FIRE LOOKOUT STATIONS IN THE REDDING FIRE WEATHER DISTRICT.

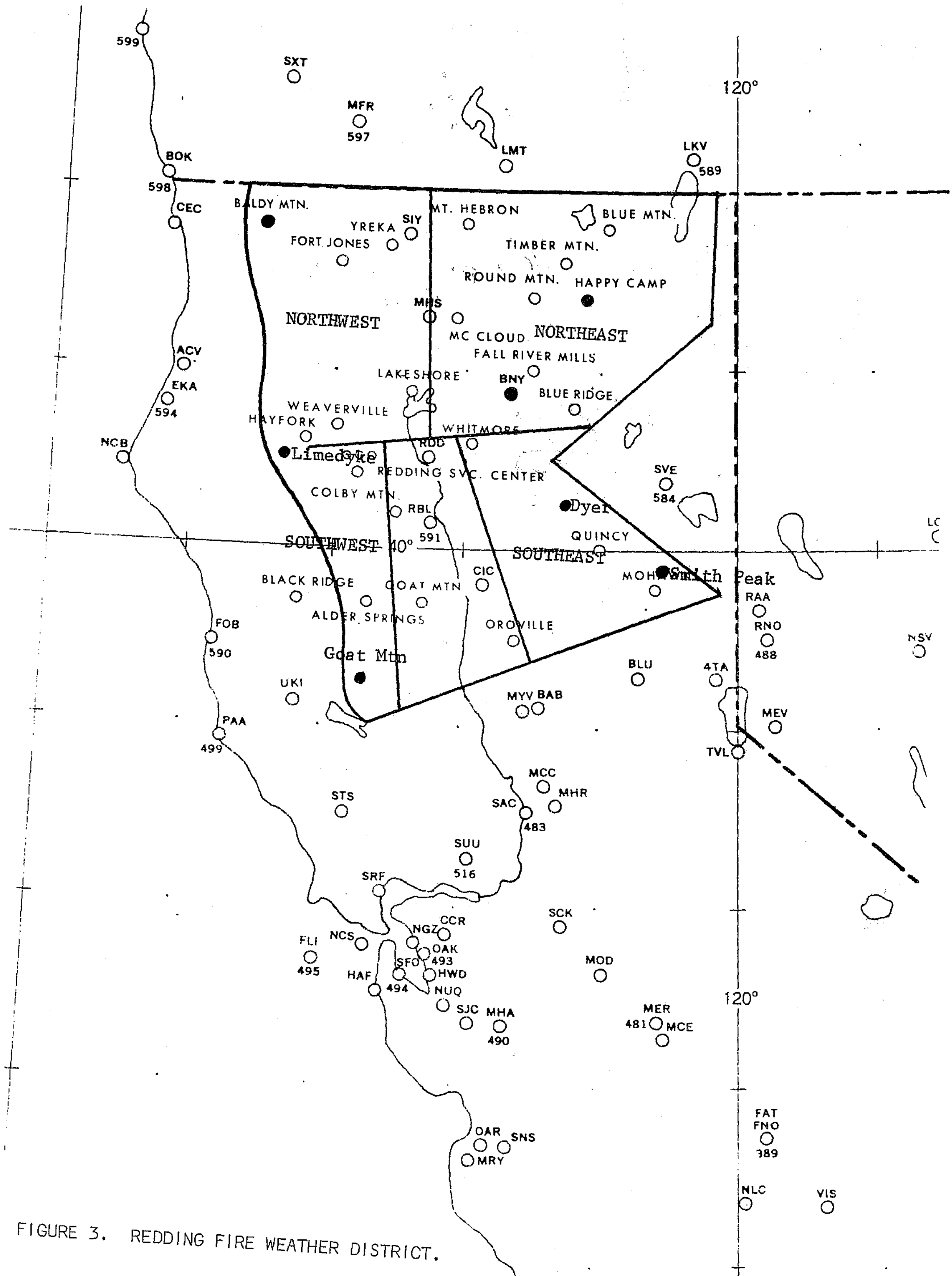

FIGURE 3. REDDING FIRE WEATHER DISTRICT.

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