SNOWFALL, SNOWFALL FREQUENCIES AND SNOW COVER DATA FOR NEW ENGLAND

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Some of the chlorides have found much favor in dealing with New England snow. When it comes to dealing with snowfall statistics, it also may be advisable to procure a few grains of your favorite salt, to use along with them. Because, frankly, though snow is a most obvious, and a very common, weather element, it is one of the most elusive to measure with precision.

We need not go into all the difficulties, but may point out a few. First, there is the effect of frequency of measurement. At our Weather Bureau Airport Stations, snowfall is measured each six hours. Observers are asked to watch for accumulations within the interval, so that snow falling early in the period but perhaps partly or entirely melting before the observation time will not be lost. But, though observers strive to do their best, they do have other duties. It may not always be possible to watch the snow closely enough to catch it all. Subjectivity comes into the picture. It is not unusual that two observers might come up with two different values.

But cooperative observers make but one observation a day. Sometimes considerable snow may fall on a day but be all or most gone by observation time. Also, snow starts to settle as soon as it hits the ground. If measured every six hours, the accumulation for a large storm should be greater than the same storm measured only once a day.

And the problem of drifting hardly needs a mention. This has floored some of our very best cooperative observers. One may find, in place of the snowfall amount, a note: "Impossible to measure." This may be a most realistic appraisal, not a flippant excuse. Yet, we of course prefer that the observer on the spot make some kind of best estimate, so that our records may be reasonable and at least appear to be complete. For purposes of this study, we had to fill in these missing values by estimation. Another difficulty, especially acute at many Airport Stations, is the lack of suitable open space for the observation of snow-cover where not affected by local activities of man.

But we have to make the best of what we have. In spite of the difficulties, much good snowfall data exist. We prefer to present this paper as a progress report rather than the last word on the study of New England snowfall. Much data remains to be analyzed. We have been working at this project about 10 years. In all, 95 New England stations have contributed to the results presented here. Many of these stations were processed for use in describing the climate of many cities and towns for which we have published a single sheet Climatological Summary, in cooperation with a local Chamber of Commerce or some other sponsor. Others were done to provide similar data for climatic summaries for counties to be published by the USDA Soil Conservation Service. Others have been done just to fill in gaps to make this paper more complete.

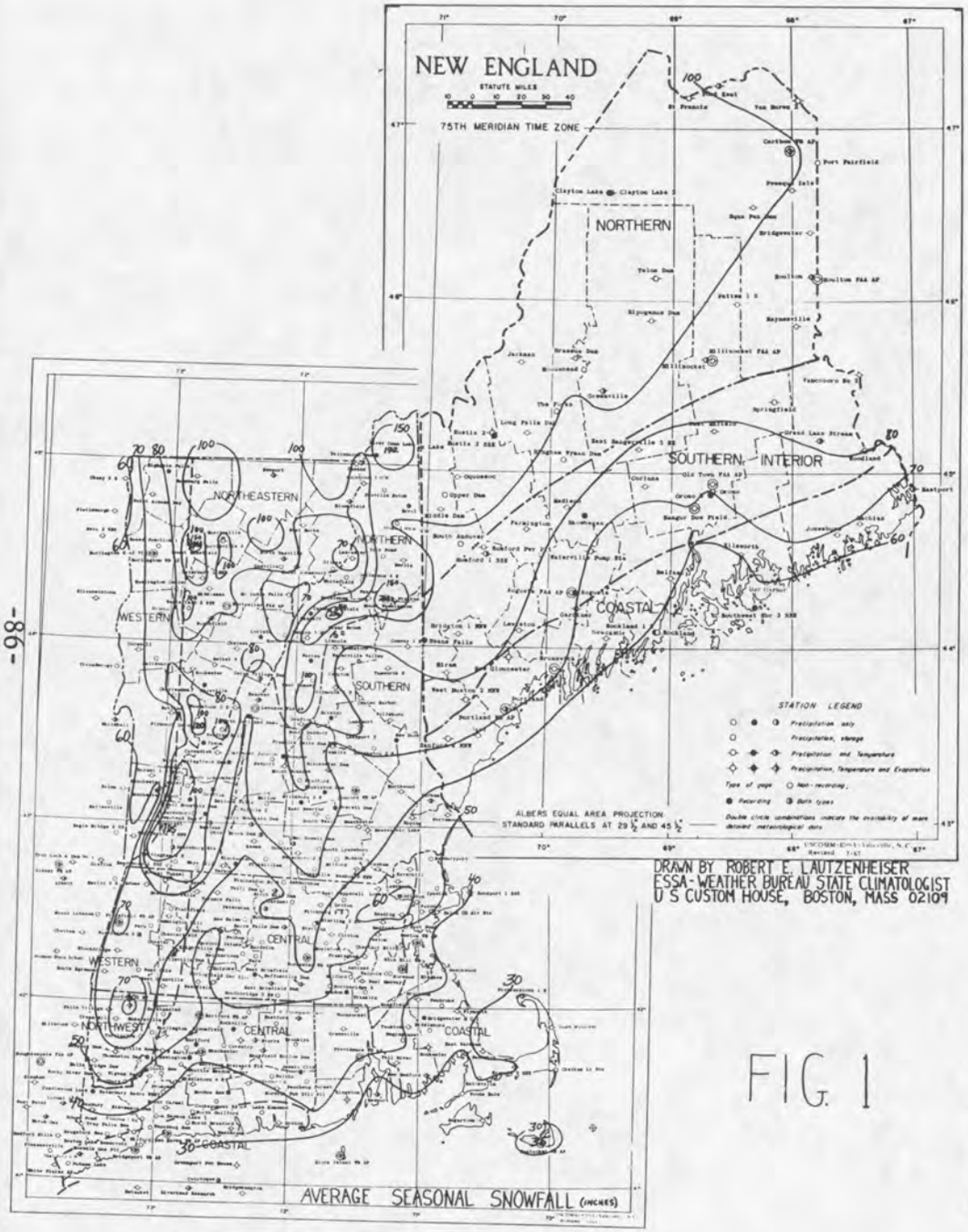

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FIG. 1

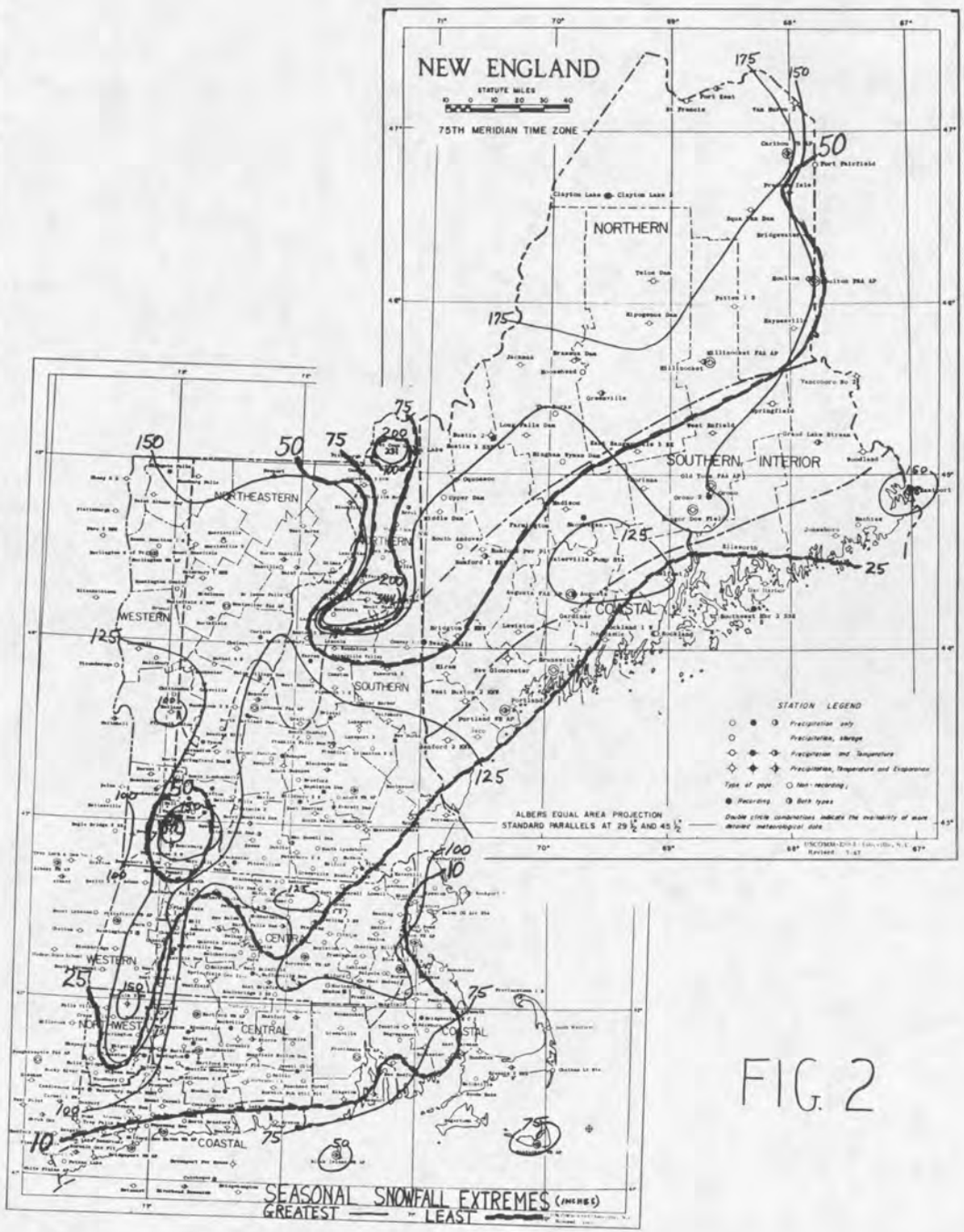

FIG. 2

As this work progresses in the future, we may be able to present a revised and more realistic picture of New England snowfall.

One should keep in mind that the vast majority of our weather stations are located in population centers, large or small. These centers tend to be in the valleys and plains. The snowfall maps we will be showing you therefore may fairly well represent conditions where most people live. But they disregard, to an extent, the more snowy conditions which may exist in the hills. This factor may especially effect data on maximum snow cover, for various reasons. Just one effect in urban areas is the rapid deposition of soot and other dirt on the snow cover. This rapidly increases melting by the sun.

For many stations, around 30 years of record were used, though for some it is as short as 10 years. An exception is the seasonal extremes of snowfall, where we began with Joseph Galway's work on "Statistical Studies of New England Snowfall." These seasonal extremes go back into the 1800's in many cases, as far as 1870 in one case. The updating of Galway's work is not complete, so that some new records set since 1950 may not appear.

Figure 1 is the average seasonal snowfall total in inches. Right away, you may note that what we said about most of the stations being generally in the valleys and towns did not prevent us from throwing in our heaviest average, from the station at the top of the Cannon Mt. Aerial Tramway, 216 inches. Even the summit of Mt. Washington is shown, though the extreme winds at that location make any measurement of snowfall there more of an art and less of a science. But in general, we find totals of near 30 inches along the extreme southern coast, with nearly 60 inches along the Maine coast and over much of Massachusetts and even along the Champlain Valley of Vermont. From there we go to over 100 inches in northwestern Maine and highland areas of New Hampshire and Vermont. You will note the 125 inches as far south as southern Vermont. The lack of detail in northwestern Maine may be due considerably to the lack of a dense network of stations. I should say here, that this map is based upon all stations with available averages, not just the 95 for which snowfall frequencies were computed. The effect of the lowlands along the Connecticut River in reducing snowfall is apparent along its whole length, excepting its source.

Figure 2 shows snowfall totals for extreme seasons. The greatest ranges from only 48 inches for Block Island to 344 inches on Mt. Washington. But generally it is from 75 to 100 in south coastal areas and 125 or so along the Maine coast, with only limited areas having more than 150 inches on the record books. On the low side we have values under 10 inches generally along the southern coast, 25 inches along the coast of Maine and down through much of Massachusetts. Only very limited areas get more than 75 inches every winter.

Figure 3 gives the average number of days on which the snowfall record shows 1 inch or more. This does not mean the number of snowstorms of 1 inch or more, as the same storm might be recorded on 2 or more days. On the other hand some snowstorms, say of 1.5 inches, might fall with 0.7 inch on one day and 0.8 inch on the next and not get counted here at all. As these effects tend to cancel, these values might be used also as

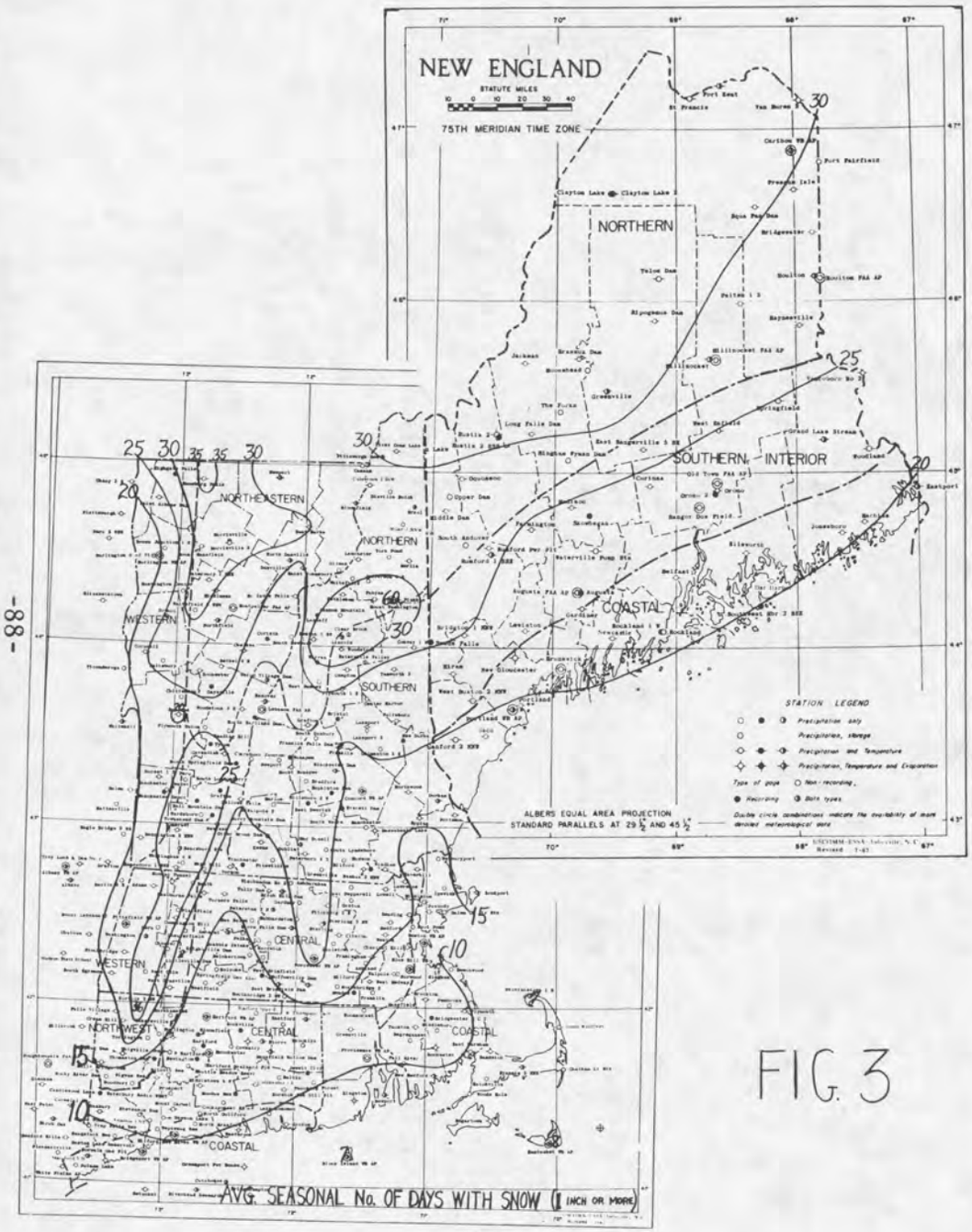
NEW ENGLAND
STATUTE MILES
75TH MERIDIAN TIME ZONE
NORTHERN
SOUTHERN INTERIOR
NORTHEASTERN
WESTERN
SOUTHERN
COASTAL
CENTRAL
NORTHWEST
STATION LEGEND
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS AT 29½ AND 45½
AVG. SEASONAL No. OF DAYS WITH SNOW (1 INCH OR MORE)

FIG. 3

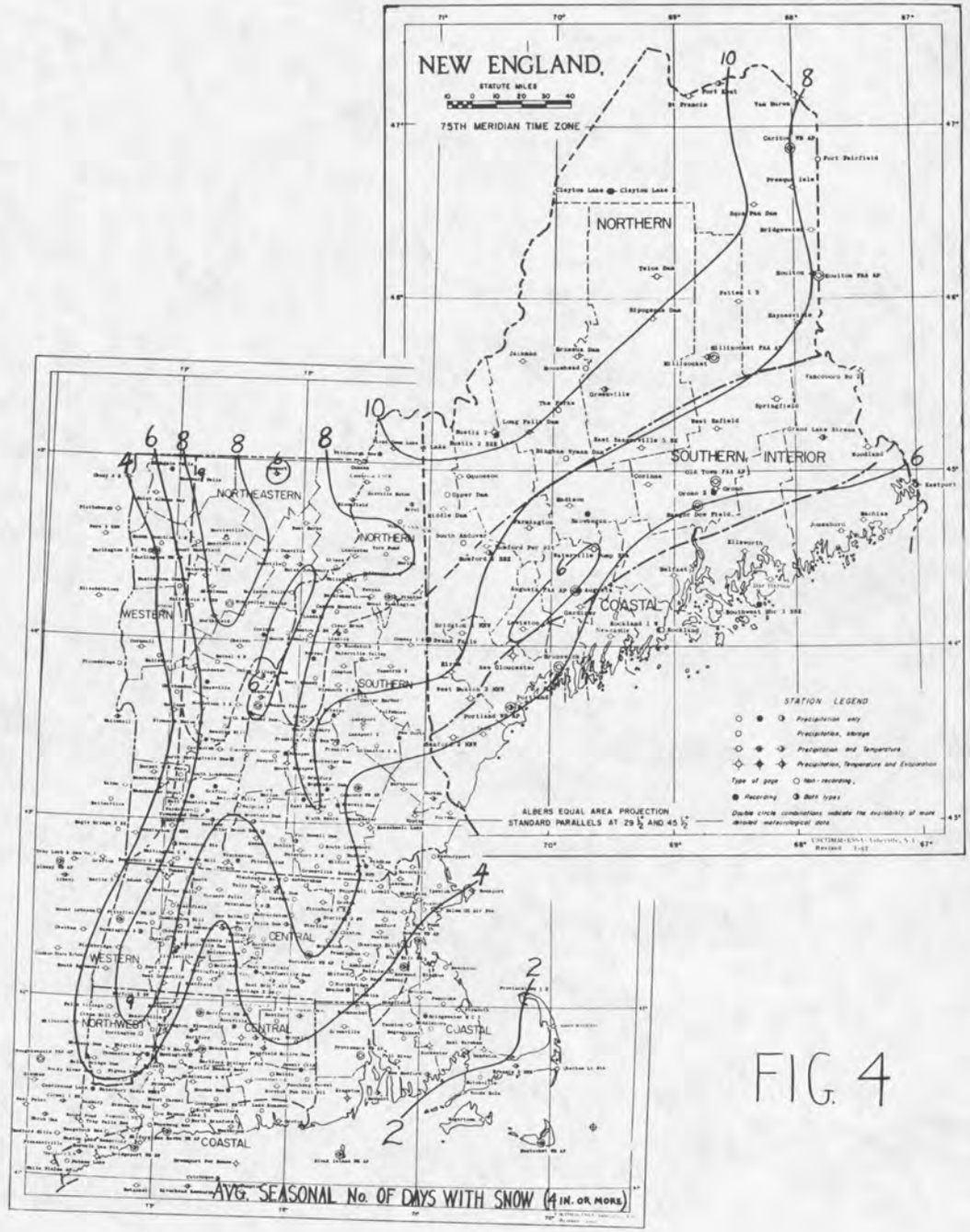
NEW ENGLAND
STATUTE MILES
75TH MERIDIAN TIME ZONE
NORTHERN
SOUTHERN INTERIOR
NORTHEASTERN
WESTERN
SOUTHERN
COASTAL
CENTRAL
NORTHWEST
STATION LEGEND
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS AT 29½ AND 45½
AVG. SEASONAL No. OF DAYS WITH SNOW (4 IN. OR MORE)

FIG. 4

estimates of the number of storms, but no claim is made in this regard. We find only 10 or less in the extreme southeast but a definite increase in frequency as one goes north or to higher elevations. Not too many areas have 30 or more days, but one of these is way down in Connecticut. This station at Norfolk, Connecticut, is in an especially snowy location on a north slope of a hill. There probably are many other similar locations in the northwestern Connecticut hills and also in the Massachusetts Berkshires, but we didn't have station data to back this up. As a matter of fact, this average of 36 at Norfolk is as great as any place plotted on the map, with the exception of the area of New Hampshire's Presidential Range.

Figure 4 shows a similar display but for the four-inch level. The general distribution follows very similar patterns to those for days with one inch. We have only 2 in the extreme southeast, increasing to 8-10 in the mountain areas and to more than 10 in northwestern Maine. We have no value plotted for Mt. Washington.

In figure 5, we find the averages for snowfalls of 8 inches or more. Surprise or not, we do not here find the many-fold increase from one area to another. Few areas have less than 1 case and not many have more than two. Furthermore, some of the areas with two are as far south as Massachusetts. The explanation for this phenomenon may be the occurrence of our coastal "northeasters." These storms occasionally dump heavy snows in southeastern sections while leaving, at least sometimes, much lighter amounts to the northwest.

Figure 6 shows the average seasonal maximum accumulation of snow on the ground. This ranges from near 10 inches in the extreme south to 20 to 30 inches over most inland areas, and up to over 40 inches in northwestern Maine. Here, again, I would point out that these are weather station values. No doubt that many hills and slopes, and perhaps many of our popular ski areas have greater average depths than shown here. The small figures you see on the map for some stations are the record low and record high values of the maximum depths. The extreme maxima range from around 20 inches farthest south to mostly 30 to 50 inches inland, but with some higher values. The lowest values range from only one inch in some coastal areas to mostly around a foot in the northern interior.

I thought it might be interesting to take a look at the average date of the seasonal maximum depth. Figure 7 displays these average dates. Frankly, I expected to find more of a definite pattern toward later dates in the highlands and northern interior areas. There the snowfall might be expected to keep on accumulating faster than depletion by melting, evaporation, or settling on account of the low temperatures and generally greater seasonal snowfalls. While this effect does show up , it is not too marked. For much of the section, the average date is not too far from the middle of February. I think one explanation of the relatively late average dates in the southeastern coastal areas is the occurrence of seasonal maximum depths produced by a single storm, one of our famous northeasters. These have come frequently in March in many of the recent years, all of which went into the averages shown here.

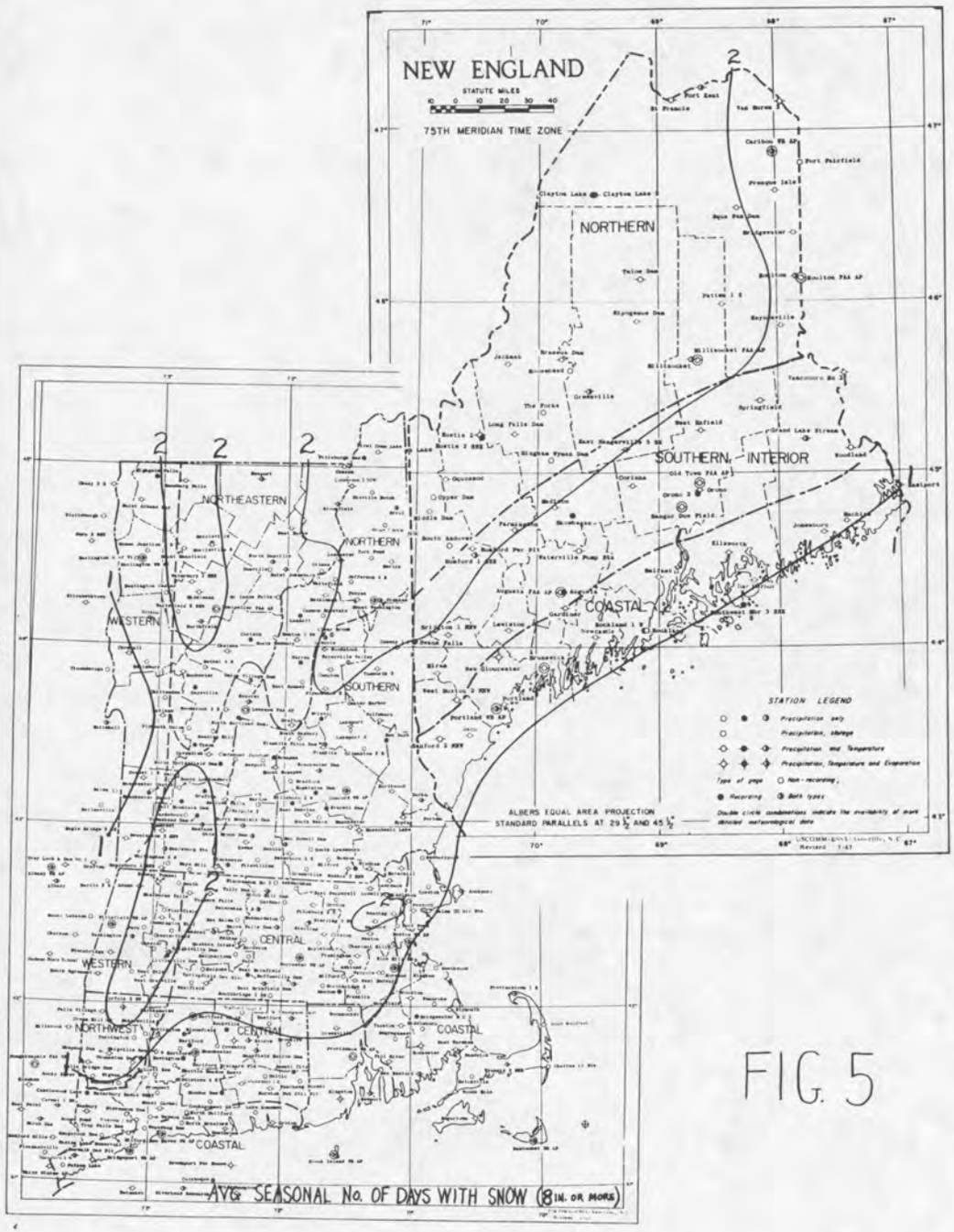
NEW ENGLAND
STATUTE MILES
75TH MERIDIAN TIME ZONE
NORTHERN
SOUTHERN INTERIOR
NORTHEASTERN
WESTERN
SOUTHERN
COASTAL
CENTRAL
NORTHWEST
STATION LEGEND
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS AT 29½ AND 45½
AVG SEASONAL No. OF DAYS WITH SNOW (8 IN. OR MORE)

FIG. 5

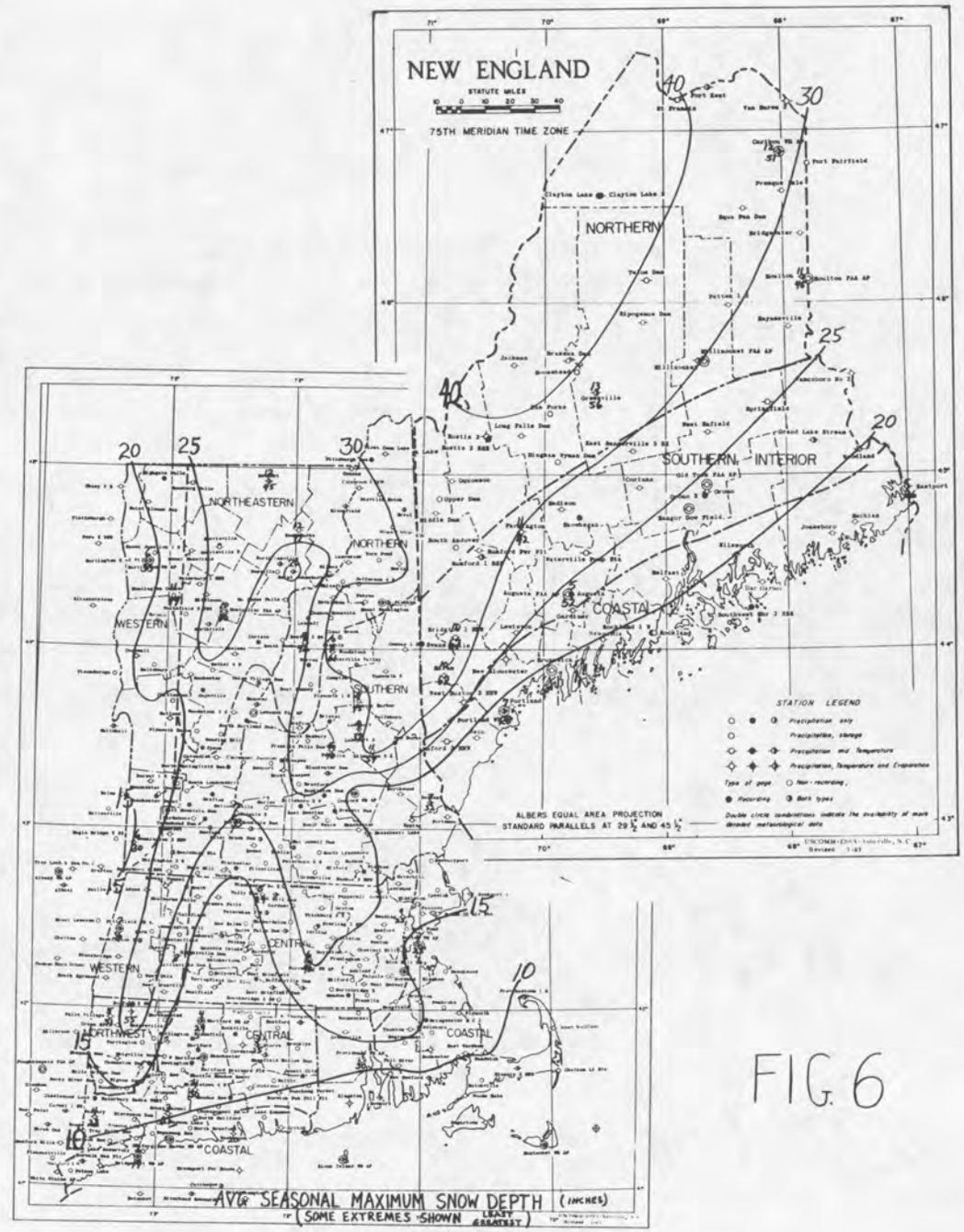
NEW ENGLAND
STATUTE MILES
75TH MERIDIAN TIME ZONE
NORTHERN
SOUTHERN INTERIOR
NORTHEASTERN
WESTERN
SOUTHERN
COASTAL
CENTRAL
NORTHWEST
STATION LEGEND
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS AT 29½ AND 45½
AVG SEASONAL MAXIMUM SNOW DEPTH (INCHES)
(SOME EXTREMES SHOWN LEAST GREATEST)

FIG. 6

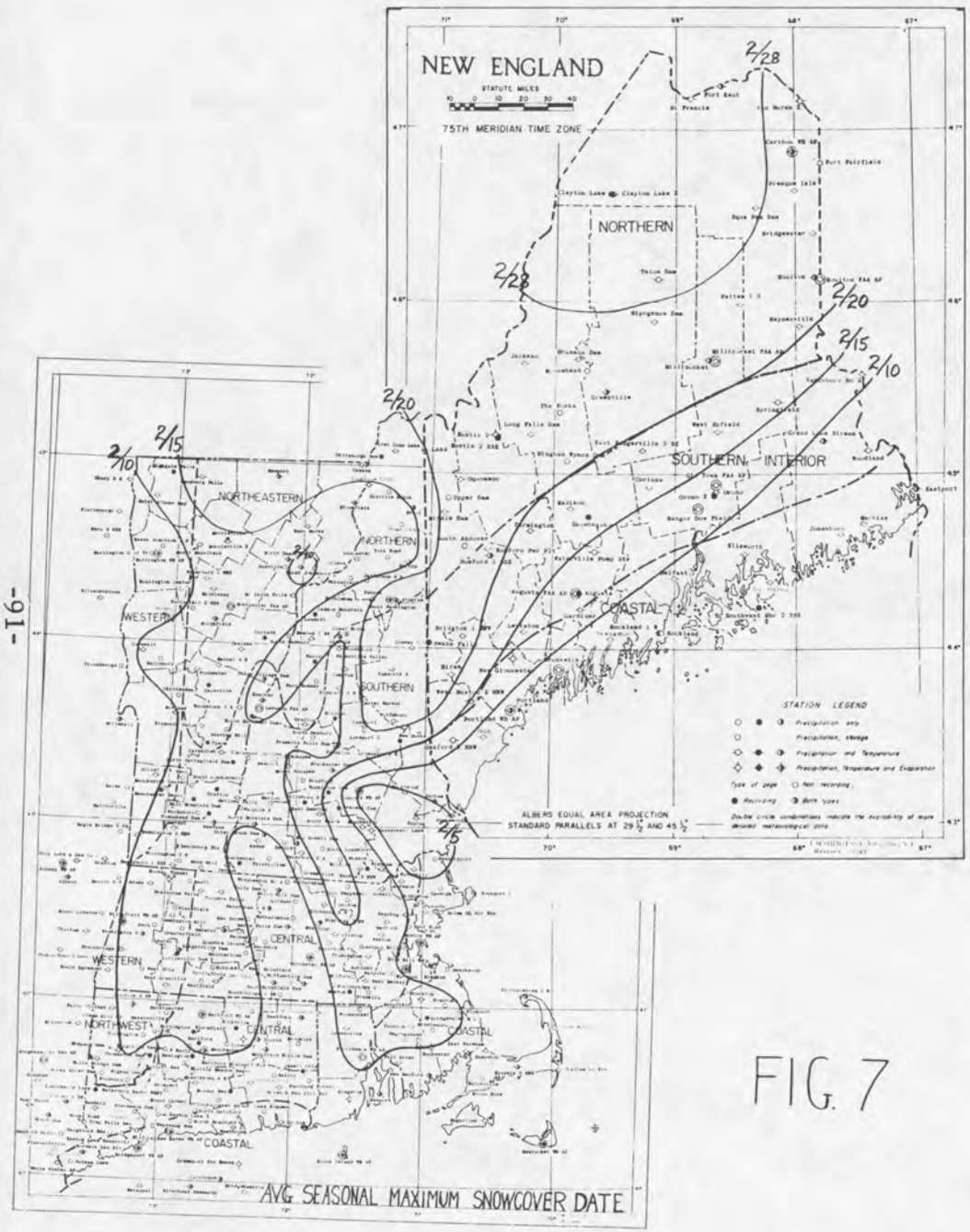
NEW ENGLAND
STATUTE MILES
75TH MERIDIAN TIME ZONE
NORTHERN
NORTHEASTERN
WESTERN
SOUTHERN
SOUTHERN INTERIOR
COASTAL
CENTRAL
NORTHWEST
2/28
2/20
2/15
2/10
2/5
STATION LEGEND
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS AT 29½ AND 45½
AVG SEASONAL MAXIMUM SNOWCOVER DATE

FIG. 7

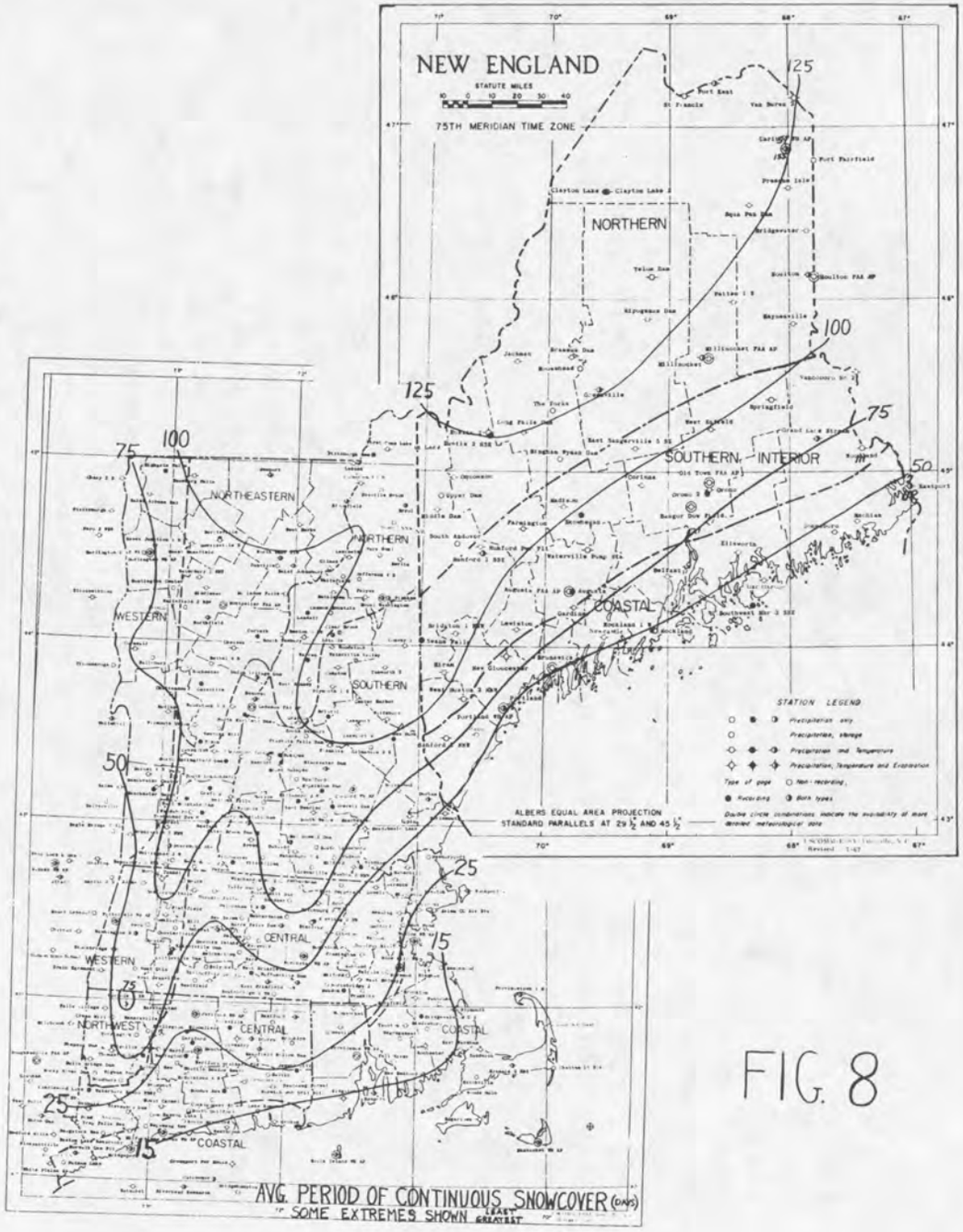
NEW ENGLAND
STATUTE MILES
75TH MERIDIAN TIME ZONE
NORTHERN
NORTHEASTERN
WESTERN
SOUTHERN
SOUTHERN INTERIOR
COASTAL
CENTRAL
NORTHWEST
125
100
75
50
25
15
STATION LEGEND
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS AT 29½ AND 45½
AVG. PERIOD OF CONTINUOUS SNOWCOVER (DAYS)
SOME EXTREMES SHOWN GREATEST

FIG. 8

Our last map, figure 8, shows the average length of the seasonal longest period of continuous snow cover. This is defined as a cover of an average depth of one inch or more, where anything over a half inch is called an inch. Generally, when there is an inch or more on the ground, most of the surface will be covered. This would not always be so, and certainly the ground need not be completely covered to still count in this tally. Cape Cod and southern coastal areas come up with less than 15 days on the average, but this rapidly increases northward to more than four months in northern Maine. This persistence of snowcover in the north furnishes excellent insulation of the soil. There it frequently limits any significant freezing of the ground to streets and other snowplowed areas and other places becoming naturally bare, as from the wind. In the areas of short cover periods, the dates of the longest cover may come anytime from very early in the winter to very late. In the north, the beginning dates range considerably, but the ending dates appear to be somewhat limited by the calendar, as the sun gets higher into the sky.

We will conclude with a few notes on the distribution of daily snowfalls by the various months. Table 1 gives the distribution for snowfalls of 1 inch or more, where we find at least a few occurrences over the period of record as early as October. For Caribou, Maine, the October average is 1. These increase to a maximum for most stations in January, though at some stations, February has more, despite its being a shorter month. The January frequency rises to as high as 8 at one of the Vermont stations shown, and is 8 each for both January and February for our snowy Connecticut station, Norfolk. This station is the only one shown with an average of 1 yet in May. On the right hand side of the table is shown the greatest and least frequencies, together with the number of years used in the analysis.

Table 2 is similar except the threshold is for four-inches. For these storms, February appears to be almost as popular as January. Again, extreme values are shown at the right.

One cannot make a study such as this on New England snowfall without sensing a great appreciation for the large number of cooperative weather observers who make and record these data. Generally they do it so well, considering the difficulties, or even the impossibilities. So I would like to take this moment to acknowledge their contribution to this Eastern Snow Conference. Also, I am indebted to Joseph Brumbach, our ESSA State Climatologist for Connecticut and Rhode Island for considerable analyzed data for stations in his area.

Footnote: Perhaps the first comperhensive study of New England snowfall was that done by Dr. Charles F. Brooks in 1917 and published in the Monthly Weather Review, the June issue of that year. Though Dr. Brooks' maps are based upon only 21 seasons, through 1916, the results are remarkably similar to those from more recent years. The next major work was that by Joseph Galway, of the Weather Bureau. Parts of his work were presented tp the 8th and 9th Meetings of the Eastern Snow Conference, in 1951 and 1952. Other parts appeared in the periodical, "Eastern Skier," in various issues from 1948 through 1951. These items were revised or brought up to date and other sections added to comprise an unpublished manuscript entitled: "A Statistical Study of New England Snowfall." A copy is on file with the State Climatologist, Custom House, Boston. This present study is not intended to replace these previous works. Rather, it is a part of a

goal to update them and to enlarge upon them, especially in regard to snowfall frequencies and snowcover. This task will continue, in the hope that eventually the essence of all these studies might appear in a single publication, readily available to all.

TABLE 1. MONTHLY AND SEASONAL FREQUENCY OF DAILY SNOWFALLS OF ONE INCH OR MORE

	O	N	D	J	F	M	A	M	TOTAL	MOST	LEAST	YEARS#
MAINE												
CARIBOU	1	3	6	7	6	5	3	*	31	46	22	27
FARMINGTON	*	2	4	6	5	5	2	*	24	33	14	30
EASTPORT	*	1	3	5	5	4	1		19	35	9	30
PORTLAND		1	3	5	5	3	1	*	18	31	9	25
NEW HAMPSHIRE												
BERLIN	*	2	5	6	6	5	2	*	26	37	14	30
WOODSTOCK	*	3	6	7	8	6	2	*	32	41	19	21
DURHAM		1	2	5	4	3	1		15	27	7	30
KEENE	*	1	3	5	4	4	1	*	18	27	10	30
VERMONT												
WEST BURKE	*	3	7	8	6	5	1	*	30	45	21	25
BURLINGTON	*	2	4	5	5	3	1	*	20	31	11	61
BENNINGTON	*	1	5	6	6	5	1	*	24	33	14	13
MASSACHUSETTS												
BOSTON		*	2	4	3	2	*		11	28	1	33
NEW BEDFORD		*	2	3	2	2	*		9	17	4	31
FITCHBURG	*	1	3	6	5	4	1	*	20	30	12	30
PITTSFIELD	*	2	5	6	6	4	1	*	23	35	17	20
CONNECTICUT												
NORFOLK	*	3	6	8	8	7	3	1	36			35
STORRS	*	1	2	4	3	3	2		14			30
NEW HAVEN	*	*	3	3	3	2	*		11			23
RHODE ISLAND												
PROVIDENCE	*	*	2	3	2	2	*		10			13

* Less than 0.5

\# Period of record used.

TABLE 2. MONTHLY AND SEASONAL FREQUENCY OF DAILY SNOWFALLS OF FOUR IN. OR MORE

	O	N	D	J	F	M	A	M	TOTAL	MOST	LEAST	YEARS#
MAINE												
CARIBOU	*	1	1	2	2	1	*	*	7	16	2	27
FARMINGTON		*	1	2	2	2	*	*	7	12	4	30
EASTPORT		*	1	2	1	1	*		5	10	0	30
PORTLAND		**	1	2	2	1	*	*	6	10	1	25
NEW HAMPSHIRE												
BERLIN	*	1	1	1	2	2	*	*	7	12	1	30
WOODSTOCK		*	2	3	2	2	*	*	9	13	4	21
DURHAM		*	1	2	1	1	*		5	12	0	30
KEENE		*	1	2	1	1	*		5	9	0	30
VERMONT												
WEST BURKE		1	1	2	2	1	*	*	7	12	2	25
BURLINGTON	*	*	1	1	1	1	*		4	8	1	61
BENNINGTON	*	*	1	1	1	1	*		4	7	3	13
MASSACHUSETTS												
BOSTON		*	*	1	1	1	*		3	9	0	33
NEW BEDFORD		*	*	1	1	*	*		2	6	0	31
FITCHBURG		*	1	2	2	1	*		6	13	0	30
PITTSFIELD		*	1	1	2	1	*		5	13	2	20
CONNECTICUT												
NORFOLK		1	1	2	2	2	1		9			35
STORRS		*	1	1	1	1	*		4		0	30
NEW HAVEN		*	*	*	1	*	*		1		0	23

* Less than 0.5 # Period of record used.