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25 MOST SEVERE SUMMER HAILSTORMS IN ILLINOIS DURING 1915-59

by

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Changnon, S. A. "Severe Summer Hailstorms in Illinois During 1915-50. " Reprint from the Transactions of the Illinois State Academy of Science.

INTRODUCTION

One purpose of the study of hail conditions in Illinois for the Crop-Hail Insurance Actuarial Association was to investigate, on a climatological basis, days with very severe, damage-producing hailstorms. From such a study, data such as the total monetary loss from the 25 severest storms, the greatest loss from a single storm, and the temporal and geographical distributions of hailstorms could be obtained. Comparisons between these hailstorm days of the amount of area with hail, synoptic conditions, stone sizes, path sizes, areas of location, and rainfall amounts in each storm could be accomplished. By studying all these conditions, it was hoped that it might be possible to detect the conditions which best related to the amount of damage produced on a single severe hailstorm day. Most of the findings, based on a study of the 18 most severe summer hailstorm days in the 1915-50 period, concerning these various conditions have been summarized in an earlier report.[1]

To enlarge upon this earlier study, all summer hailstorm days in the 1915-59 period which had at least $50,000 in crop and property losses from hail were determined. From this list, the 50 storm days producing the greatest amount of monetary loss were selected for further study. This report has been prepared to describe the 25 most severe hailstorm days in the 1915-59 period. This second, supplementary report serves two additional purposes. The first is to display cartographically the hail patterns and related meteorological conditions for each of the 25 most severe summer hailstorms in the 1915-59 period. The second is to obtain a comparison of monetary losses produced by the severest hailstorm days in the past decade (the period when hail insurance records are most detailed) with those produced by the severest hailstorm days in the 36-year period preceding 1951.

DATA USED AND METHOD OF STORM COMPARISONS

In order to accomplish this study in which a series of storm days occurring in the 1915-59 period were to be compared, a method of normalizing the storm monetary data had to be devised. This method, which is described in detail in the earlier report, consisted of first normalizing the amount of crop damage for each storm day to the 1910-14 base of price index for crops, plus normalizing the building damage amounts to the 1910-14 base index of prices for building materials. Secondly, to adjust for temporal variations in acreage and in yield: during the 45-year period, 1915-59, the normalized crop loss amount was expressed as a percent of the annual farm value.

These two criteria were used to evaluate rank or severity of each storm day. Based upon the total amount of loss, normalized for both crops and property, each of the 50 storm days was ranked and arrayed from high to low with the highest rank, rank one, being the storm with the greatest amount of monetary loss. The 50 storm days also were ranked according to the percent of the annual farm value lost. The ranks for both of these categories, determined for each storm day," were used to compute an average rank for each storm day. These 50 average ranks for the 50 storm days were then compared in order to select the 25 highest" ranked, or most severe hailstorm days during the 45-year period.

The procedure used to obtain the amount of storm monetary loss from historical records was identical to that reported in the earlier report. [1] In this procedure, damage amounts were determined utilizing published U. S. Weather Bureau data, crop-hail insurance records, newspaper reports, and unofficial storm reports and records of the U. S. Weather Bureau.

FINDINGS

Temporal Distribution of Hailstorms

In order to have a sufficiently large sample of storm days to permit a reliable study of temporal variations on an annual or longer-period basis, the temporal distributions of storm days were studied utilizing the dates of the 50 selected storms rather than those of the 25 most severe storms. The dates of these 50 storms are shown in Tables 1 and 2. On an annual basis, 1954 with 6 storm days had the greatest number followed by 1927 with 4 storm days. Several years, 1924, 1925, 1938, 1940, 1948, and 1956 each had 3 of the 50 severe summer hailstorm days. Twenty years in the 1915-59 period recorded none of the 50 days with severe summer hailstorms.

To further examine the temporal distribution, the number of severe summer hailstorm days occurring in each 5-year period, beginning with 1915, was computed. The 5-year period with the greatest number was the 1925-29 period which had 10 storm days followed by the 1950-54 period with 9 storm days. The 1930-34 and 1935-39 periods each had 7 days, and the 1940-44 and 1945-49 periods each had 5. Four severe summer hailstorm days occurred in the 1955-59 period with 2 occurring in the 1920-24 period and one in the 1915-19 period.

The number of severe summer hailstorm days per decade, beginning with 1920, was also investigated. This showed that in the 1920-29 period 12 storm days occurred with 14 in the 1930-39 period. The 1940-49 decade had 10 days with severe summer hailstorms with 13 days in the 1950-59 decade. Based on the 10-year frequencies, it appears that the temporal distribution of severe summer hailstorm

days is rather uniform. However, on an annual and a 5-year period basis, temporal fluctuations in the number of severe hailstorm days are much greater.

Monetary Losses Incurred on the 25 Severest Summer Hailstorm Days

Normalized monetary losses produced by the 25 most severe storm days ranged from a high of $3, 172, 508 for one storm day to a low of $112, 472. A summary of losses for each storm day, as presented in. Table 1, shows that losses from crop damages accounted for a large portion of the total loss for most storm days. In only one storm day, July 10, 1934, did the property damage loss exceed the crop damage loss, and on 5 storm days property losses less than $500 were recorded. The total normalized loss for the 25 storm days was $13, 944, 398 with an average of $774, 688 per storm.

The right hand column in Table 1 lists, for each storm day, the percent of annual farm value lost because of the amount of crop damage. This was the second major factor, discussed earlier, used to evaluate the storm days. A wide range existed in these values (Table 1), from 0.02 percent up to 0. 38 percent with an average of 0.09 percent loss per storm.

TABLE 1

MONETARY LOSSES AND PER CENT OF ANNUAL FARM VALUE LOST BY DAMAGES PRODUCED BY 25 MOST SEVERE SUMMER HAILSTORM DAYS, 1915-59

Rank	Storm date	Total storm loss, in thousands of dollars, normalized to 1910-14 price indices	Per cent of total storm loss		Total storm crop loss as a per cent of annual farm value
			Crop damages	Property damages	
1	8/17/48	3,173	99.8	0.2	0.26
2	7/28/43	2,719	88.0	12.0	0.31
3	7/22-23/31	665	99.8	0.2	0.38
4	7/10/34	1,152	43.5	56.5	0.20
5	6/20-21/15	399	85.1	14.9	0.08
6	7/13/34	351	98.8	1.2	0.14
7	6/14/48	503	95.0	5.0	0.04
8	8/29/48	478	100.0	0.0	0.04
9	8/18/25	351	100.0	0.0	0.08
10	7/1-2/33	273	100.0	0.0	0.13
11	8/7/53	444	96.7	3.3	0.03
12	8/9/54	411	99.6	0.4	0.03
13	8/18/46	410	97.6	2.4	0.03
14	7/6/54	452	80.9	19.1	0.03
15	8/9/25	265	100.0	0.0	0.06
16	7/24/25	255	98.8	1.2	0.06
17	8/9/32	134	82.2	17.8	0.06
18	6/10/58	291	100.0	0.0	0.02
19	7/10/30	112	97.2	2.8	0.04
20	7/19/56	292	98.3	1.7	0.02
21	7/25/38	118	76.8	23.2	0.03
22	6/25/44	214	80.9	19.1	0.02
23	8/3-4/54	246	98.8	1.2	0.02
24	6/5/24	118	97.3	2.7	0.02
25	7/21/27	116	97.3	2.7	0.03

TABLE 2

DATES OF THE HAILSTORMS RANKED 26 THROUGH 50 IN THE 1915-59 PERIOD

Rank	Date	Rank	Date
26-	July 22, 1938	39-	August 12, 1940
27-	June 12, 1924	40-	June 25, 1926
28-	July 7-8, 1956	41-	July 17, 1956
29-	July 3-4, 1954	42-	August 2, 1954
30-	June 21, 1935	43-	August 18, 1954
31-	July 19, 1927	44-	July 5, '1953
32-	June 20, 1924	45-	August 25, 1939
33-	July 6, 1930	46-	June 30, 1926
34-	June 27, 1951	47-	June 12, 1946
35-	July 29, 1944	48-	June 10, 1939
36-	July 6, 1927	49-	August 7, 1942
37-	August 6, 1927	50-	July 4, 1937
38-	July 11, 1938		

Maps for each of these 25 severe summer hailstorms are presented in Figures 1-4. The areal distribution of hail, both damaging and non-damaging, is denoted by county occurrences on these maps. From these maps the relationship of the hail area with rainfall also can be denoted. Synoptic types, maximum stone sizes, and time of occurrence data are also presented.

A comparison of the storm days in the 1951-59 period with those in the 1915-50 period can be made by examining Table 1, Six of the 25 storms (almost 25 percent) occurred in the 1951-59 period (20 percent of the 45-year period).

Geographical Distribution of the 25 Hailstorm Days

Based on the number of times each county in Illinois experienced hail associated with storms on these 25 days, a map was prepared to reveal the areal distribution of occurrences. This map, Figure 5, has many locations where abrupt changes in the number of storms occurred. The area of greatest experience lies in northwest-central Illinois where Henry county experienced hail on 10 of the 25 days; while Warren, Whiteside, and Bureau counties had 7 or more experiences. Areas with significantly lower numbers of occurrences in the north and central areas occur from Marshall county eastward to Iroquois county, and also in the northeastern corner of the state. South of a line from Madison to Clark counties very few counties experienced more than one day with hail from the 25 storm days.

In Figure 6 the number of times each county experienced hail damage resulting from these 25 storm days is portrayed. The southern one-third of Illinois had practically no damage from these 25 storm days. Warren county with 8 days of damage had the highest number. In an average 45-year period approximately 18 summer hailstorm days occur in Warren county.(2) Inspection of this map (Fig. 6)

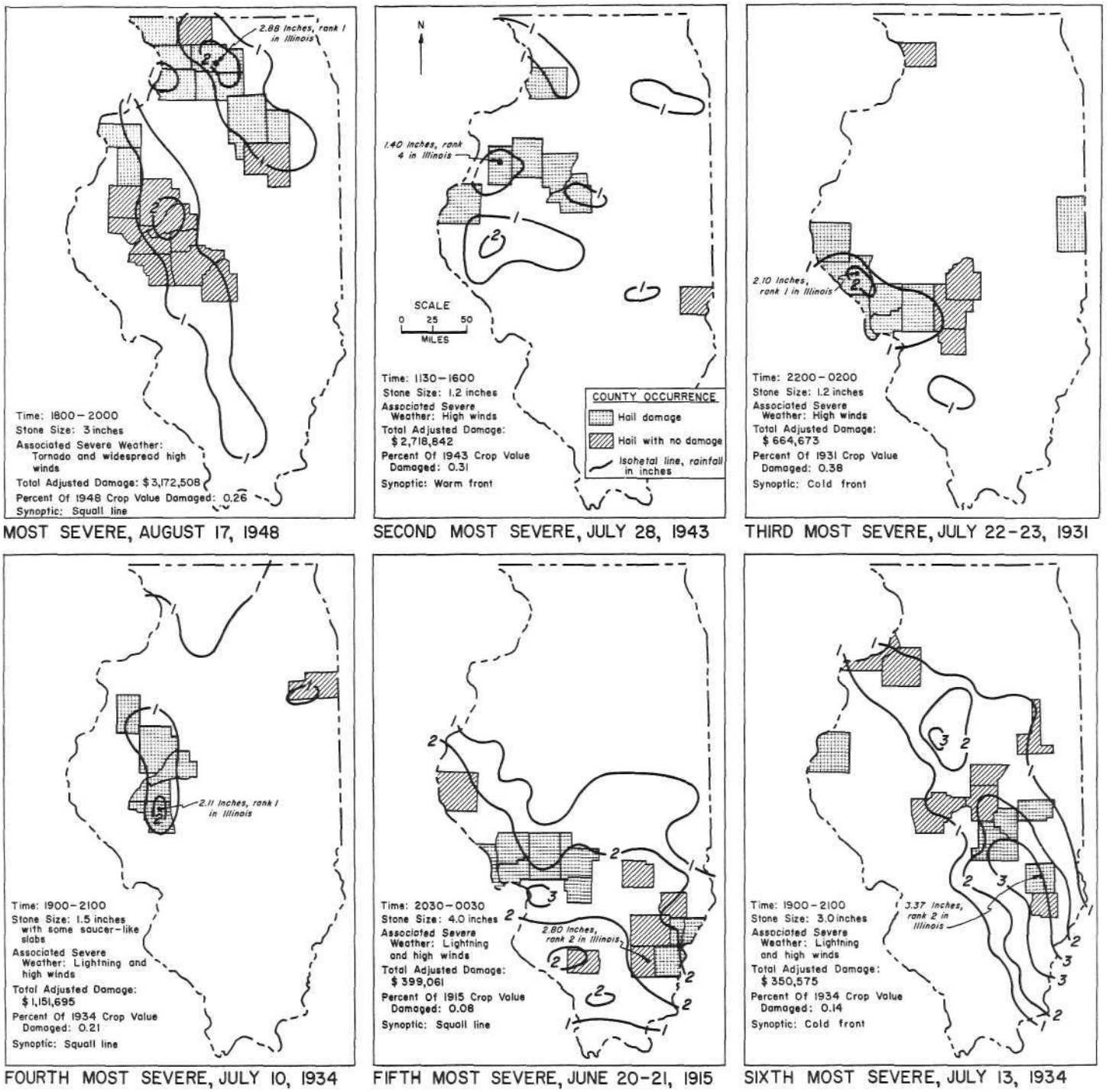

FIG. 1 SIX MOST SEVERE SUMMER HAILSTORMS IN ILLINOIS DURING 1915-59 PERIOD

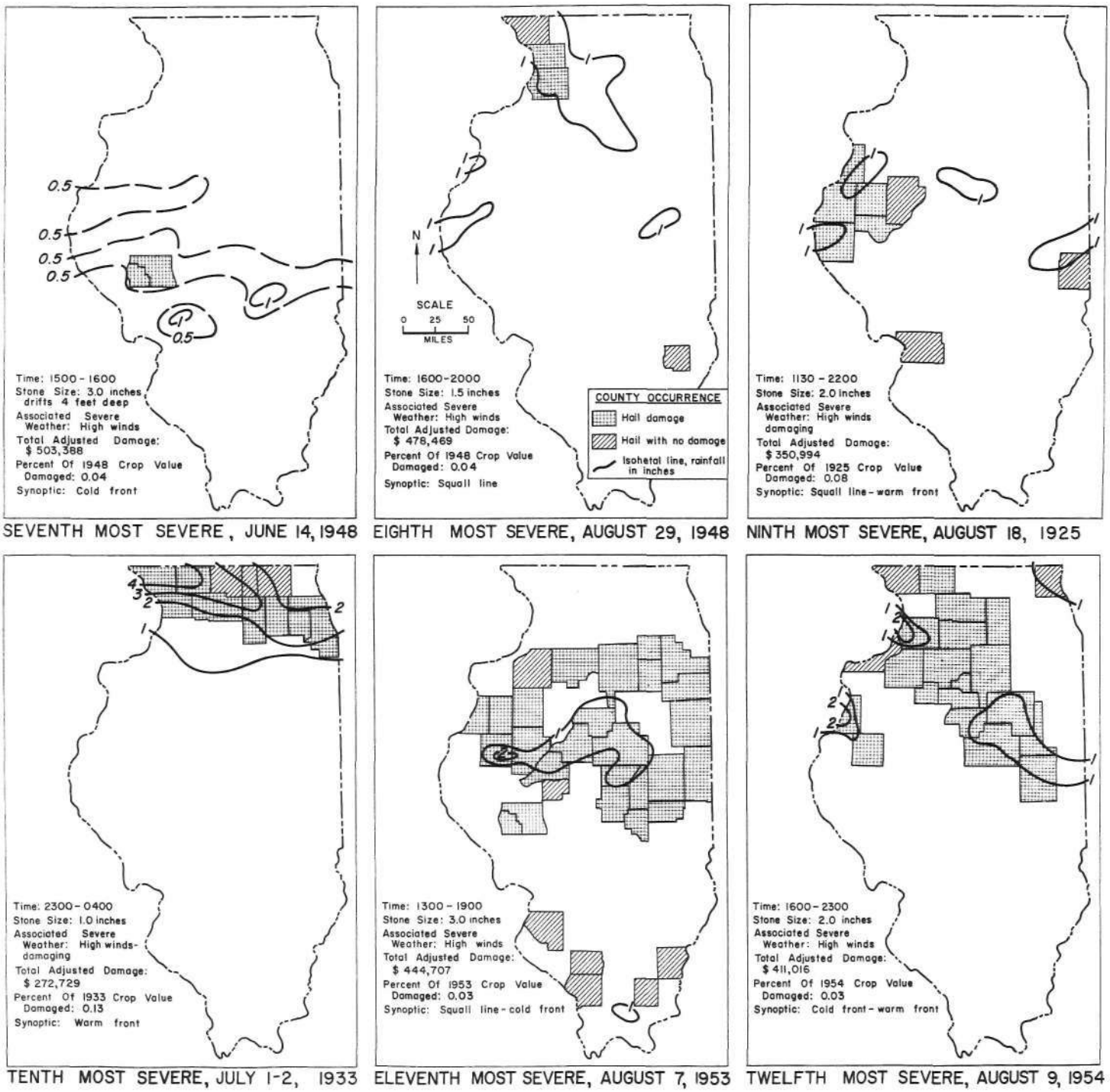

FIG. 2 SEVENTH-TWELFTH MOST SEVERE SUMMER HAILSTORMS IN ILLINOIS DURING 1915-59 PERIOD

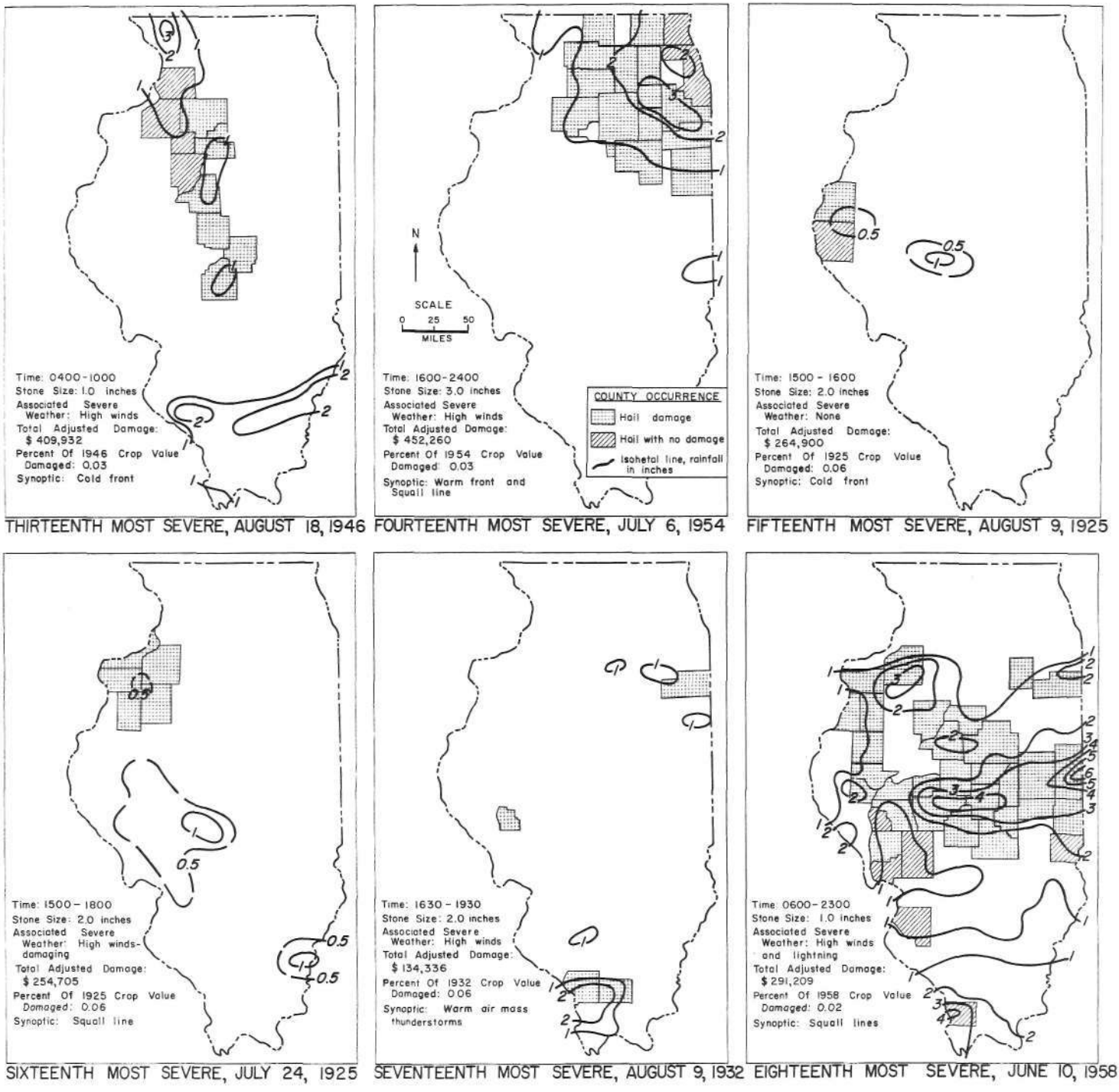

FIG. 3 THIRTEENTH-EIGHTEENTH MOST SEVERE SUMMER HAILSTORMS IN ILLINOIS DURING 1915-59 PERIOD

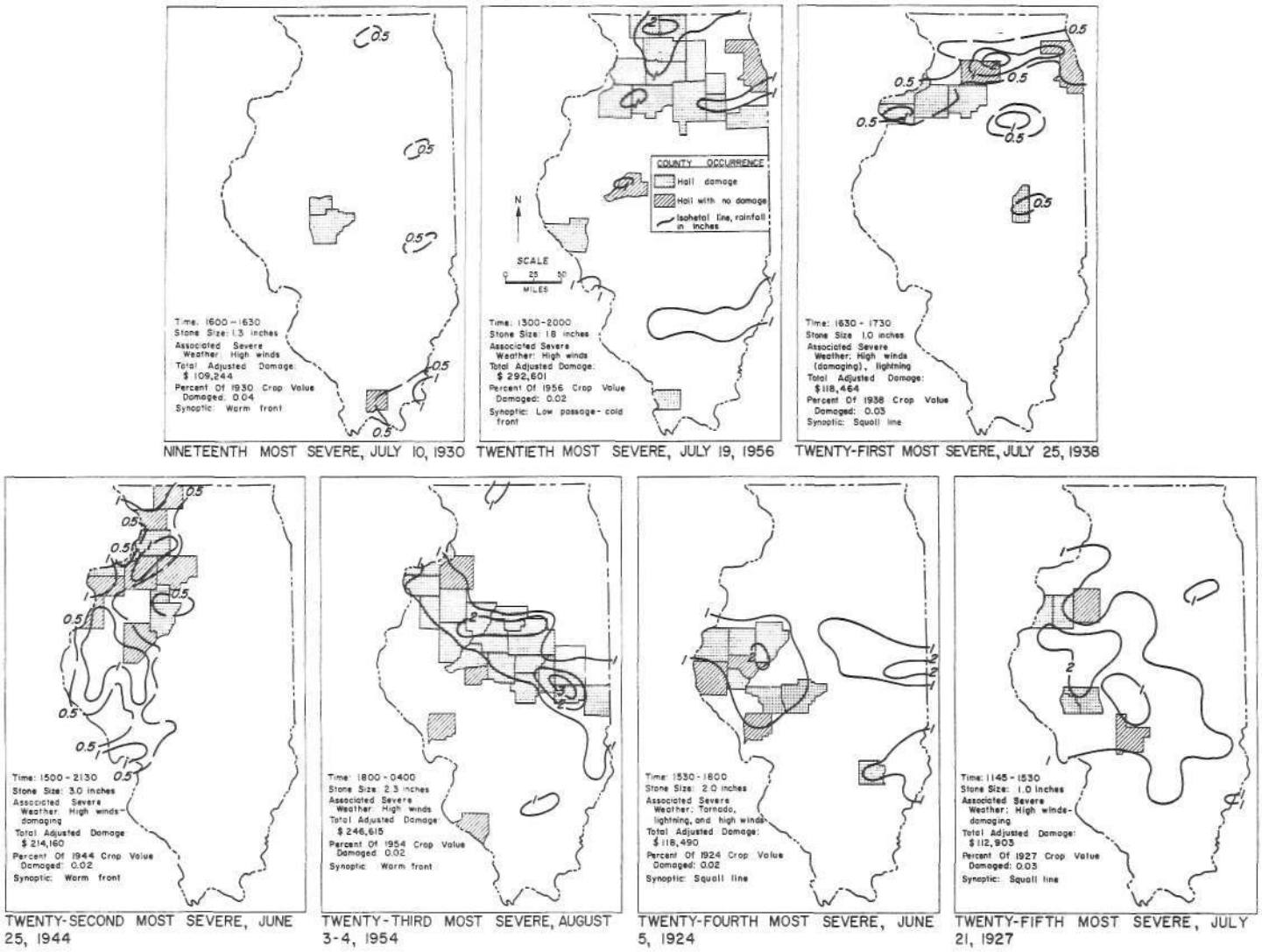

FIG. 4 NINETEENTH-TWENTY-FIFTH MOST SEVERE SUMMER HAILSTORMS IN ILLINOIS DURING 1915-59 PERIOD

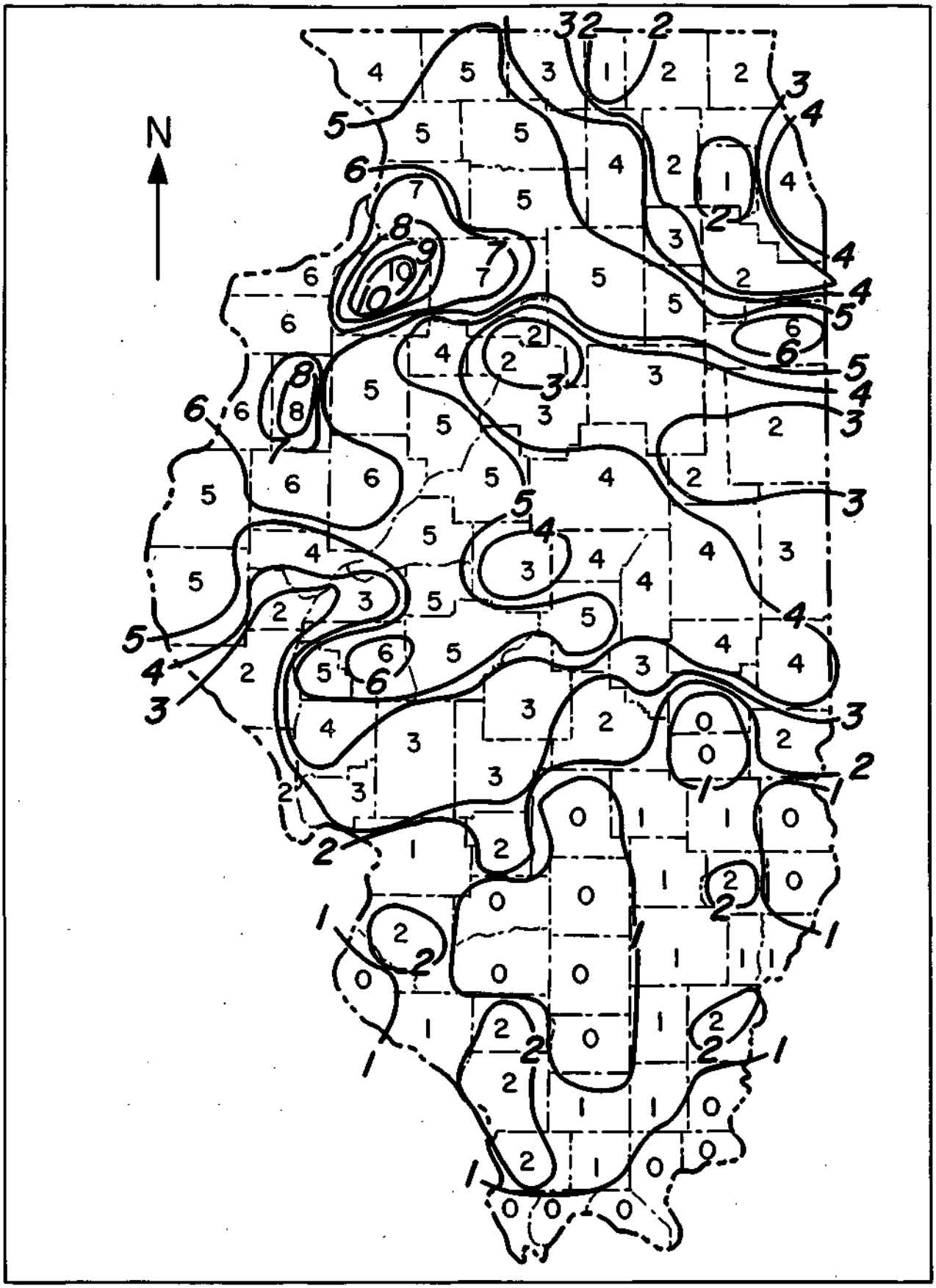

FIG. 5 NUMBER OF TIMES EACH COUNTY EXPERIENCED HAIL PRODUCED BY 25 DAYS WITH MOST SEVERE HAILSTORMS

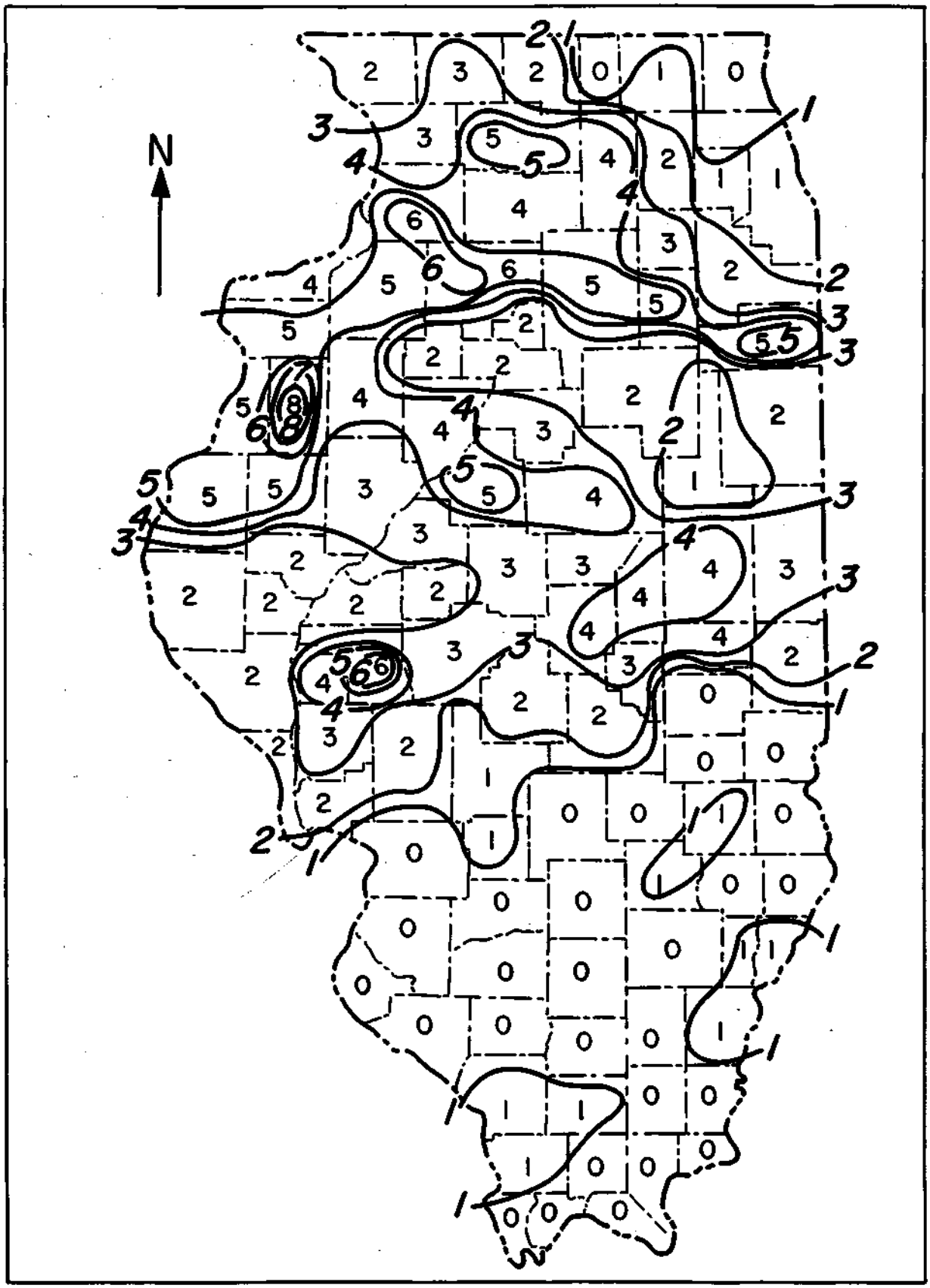

FIG. 6 NUMBER OF TIMES EACH COUNTY EXPERIENCED HAIL DAMAGE RESULTING FROM 25 DAYS WITH MOST SEVERE HAILSTORMS

reveals that these severely damaging hailstorms more frequently affected three areas in Illinois. One area extends eastward from Hancock and Henderson counties through Peoria, Tazewell, and McLean counties. A second area extends ESE from Whiteside and Ogle counties through-Bureau, LaSalle, Grundy, and Kankakee counties. A third high experience area originates in the Morgan and Scott county area and extends ENE through Macon, Piatt, and Champaign counties. Distinct areas of fewer hail damage experiences lie between these high frequency areas.

Maps similar to those of Figures 5 and 6 were prepared for the. data derived from the 50 severest hail days. These maps, Figures 7 and 8, reveal distribution patterns quite similar to those in Figures 5 and 6.

Synoptic Conditions Associated with the 25 Hailstorm Days

Detailed investigations were made of the synoptic conditions considered to be responsible for or associated with the hailstorms on the 25 storm days. Five synoptic types were found with the 25 storms. These were pre-cold frontal squall lines, cold fronts, warm and stationary fronts, warm air mass, and low pressure centers. On five storm days, two different types were responsible for hail, and these two types usually produced two distinct separate periods of hail during the day. Consequently, a total of 30 synoptic types were experienced on the 25 storm days. Twice, a combination of a squall line followed by a warm front prevailed, and squall line-cold front, warm front-cold front, and low passage-cold front combinations each occurred once. Since there were so few cases of combinations, these combinations were separated and are presented for examination in Table 3. These data reveal that squall lines were the most prevalent type. In July and

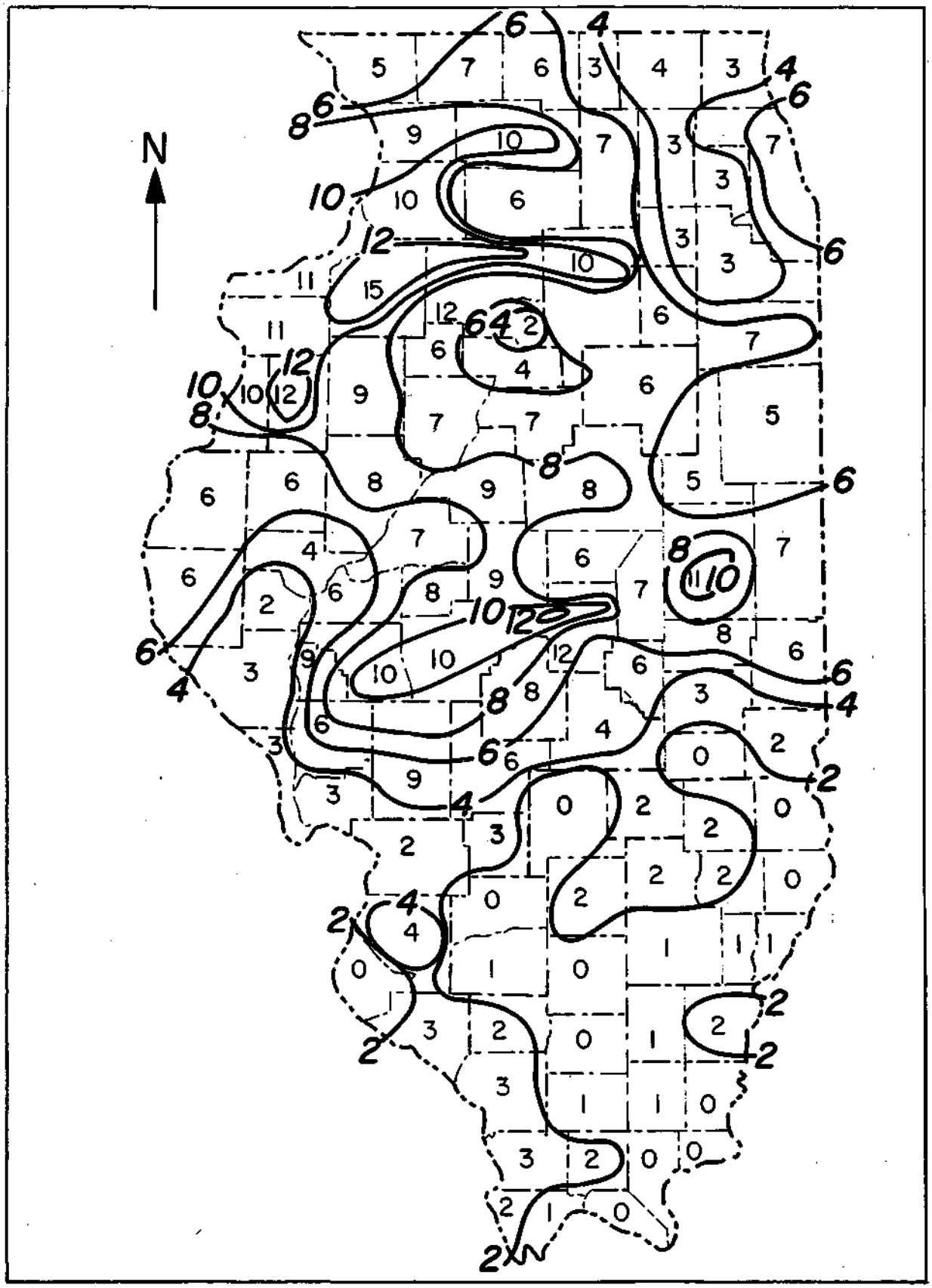

FIG. 7 NUMBER OF TIMES EACH COUNTY EXPERIENCED HAIL PRODUCED BY 50 DAYS (1915-59) WITH SEVEREST HAILSTORMS

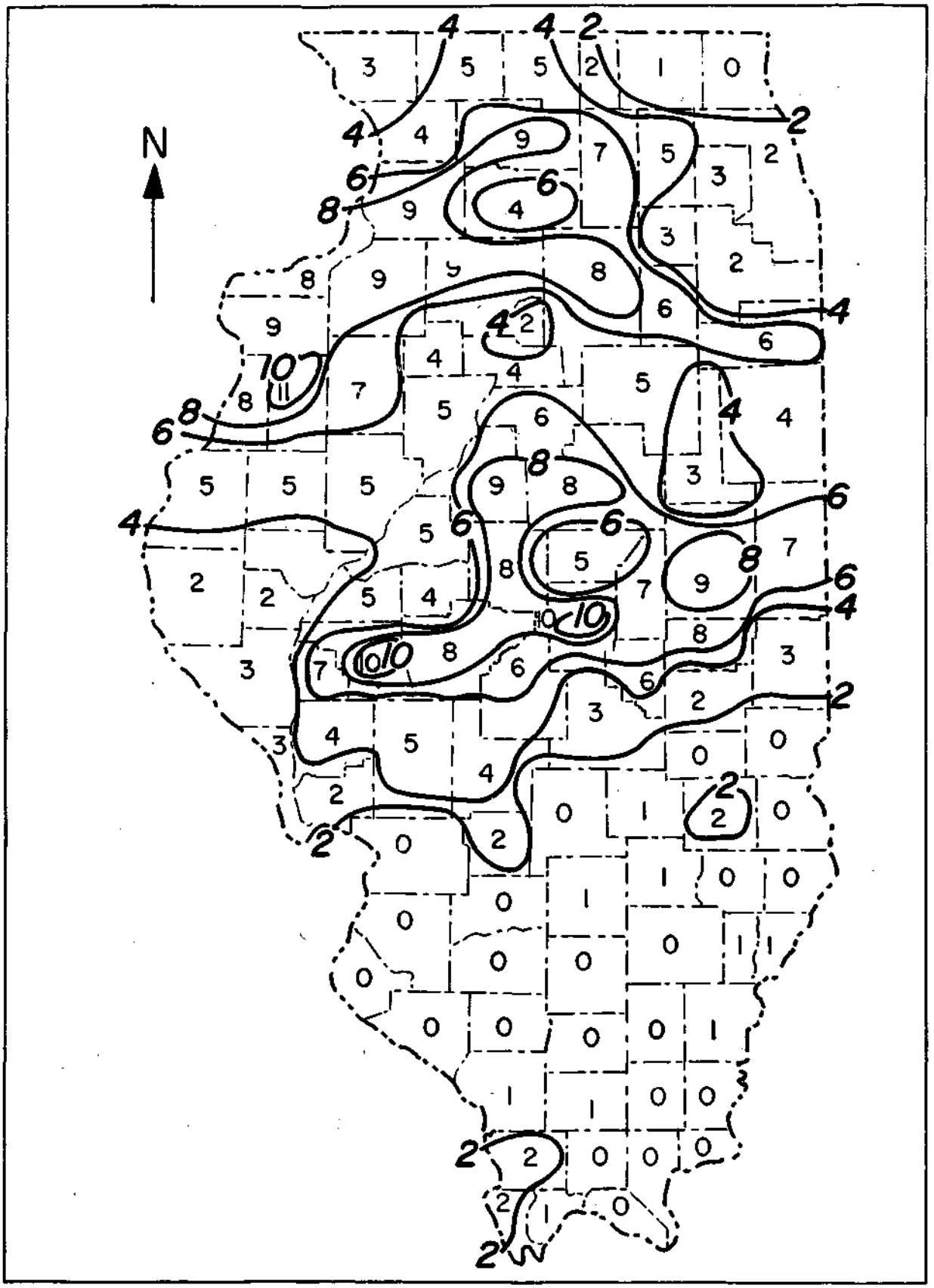

FIG. 8 NUMBER OF TIMES EACH COUNTY EXPERIENCED HAIL DAMAGE RESULTING FROM 50 DAYS WITH MOST SEVERE HAILSTORMS (1915-59)

August, the number of hail occurrences by types were almost evenly distributed between squall lines, cold fronts, and warm fronts.

TABLE 3

MONTHLY DISTRIBUTION OF SYNOPTIC TYPES ASSOCIATED WITH HAIL OCCURRENCES

Types	Months			
	June	July	August	Total
Squall Lines	3	5	4	12
Cold fronts	1	3	4	8
Warm and stationary fronts	1	4	3	8
Warm air mass	0	0	1	1
Low passage	0	1	0	1

The duration of hail periods with the three most prevalent synoptic types was compared. It was found that the median duration of hail periods associated with warm and stationary fronts was 4. 7 hours as compared to 3.0 hours for squall line periods and 2.0 hours for cold front hail periods. The preferred 4-hour period for hail initiation was from 1500 CST to 1900 CST for all synoptic types.

CONCLUSIONS

Since this report serves merely as a supplement to an earlier, more detailed report of this type,[1] a great number of details concerning these 25 storms were not presented. A detailed discussion and a summary of all the pertinent data associated with 18 of these 25 storms is presented in the earlier report. Data in this second report reveals that the worst storm in the 1951-59 period occurred on August 7, 1953. This storm achieved a rank of eleventh in relation to the worst storms in the 45-year period. Interestingly, three years during this 45-year period each had three of the severest twenty-five storms. These three years were 1948, 1925, and 1954.

Hail on these 25 storm days occurred most frequently in northwestern Illinois and hail was least frequent in southern Illinois. Almost 50 per cent of these storms were associated with pre-cold frontal squall lines. However, almost one-third of the 25 storm days had hail produced by warm fronts and another one-third by cold fronts. No single synoptic type could be attributed as the major cause of very severe hailstorms.

REFERENCES

1. Changnon, S. A., "Severe Summer Hailstorms in Illinois During 1915-50", Transactions, Vol. 53, Nos. 3 and 4, Illinois State Academy of Science, 1960. See Appendix attached.

2. Huff, F. A., and Changnon, S. A., Hail Climatology of Illinois, Report of Investigation 38, Illinois State Water Survey, Urbana, Illinois, 1959.

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SEVERE SUMMER HAILSTORMS IN ILLINOIS DURING 1915-50

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PURPOSE

As part of a hydro-climatological program for studying hail in Illinois, an investigation of days with severe summer hailstorms was made. In a 36-year period, 1915-50, the 18 days having the most severe hailstorms were selected for analysis.

One purpose of this study was to determine the amount of possible monetary loss from one storm, which is valuable information for agricultural interests and for insurance companies. Another purpose was to increase our knowledge of the meteorological characteristics at the surface displayed by severe hailstorms. It was desired to ascertain which, if any, surface characteristics of these storms correlated well with the amount of damage produced.

This study was made feasible by the availability of detailed U. S. Weather Bureau data. Large damage-producing hailstorms are well catalogued (Flora, 1956), and much more extensive data are available for these storms than for other more minor hailstorms.

Factors investigated in each storm include date and time of day, duration, maximum stone size, path size, and areal distribution. The association of the hailstorms with other types of weather, including rainfall and severe weather such as high winds and tornadoes, was studied. The types of synoptic weather producing these storms were determined also.

AVAILABLE DATA AND ANALYTICAL PROCEDURES

The original station records kept by the cooperative observers at the U. S. Weather Bureau stations in Illinois together with published and unpublished notes of the U. S. Weather Bureau furnished hail loss values for individual hail days occurring in the 1915-50 period. Summer was selected for the study period because more than 80% of the crop damage in Illinois from hail occurs in the months of June through August (Stout, Blackmer, Changnon, and Huff, 1959). It was decided to define hail severity by using the two parameters of normalized monetary loss from crop and property damages and per cent of farm value lost. Possibly, criteria such as stone sizes, path sizes, and areal distribution should be used to establish hailstorm severity in a climatological analysis, but data on these criteria are not as detailed nor as reliable as are the monetary loss data.

In order to determine the 18 most severe storm days on a monetary basis, it was necessary to normalize the data for the changing dollar value of crops and property in the 36-year period. It was also necessary to express the normalized crop loss as a per cent of the annual farm value for each year, in order to adjust the crop loss for changing acreage in crops and yield per acre. These crop losses were normalized to the 1910-14 index of prices received by farmers for grain and hay

crops (Illinois Agricultural Statistics, 1949). Similarly, property losses were normalized using index of prices paid for building materials based on the 1910-14 period. The annual farm value is a figure also normalized to this period. The 1910-14 period was used as the price reference period because of the stability of prices in that 5-year period and because Illinois agricultural statistics are based upon this period.

For each of the 40 days with the most severe hailstorms in the 1915-50 period the monetary loss from crops and property, after normalizing, and the per cent of annual farm value lost were computed. The total monetary values for each storm were compared and ranked, with rank one the highest value. The percentages of annual farm value losses for each storm also were compared and ranked, with the highest percentage assigned rank one. Therefore, for each storm, two separate rankings were obtained. These two rankings were averaged to obtain a single, final rank for each storm day. These average rankings were compared and the 18 highest ranked were selected as the 18 most severe hailstorm days in the 1915-50 period.

To measure the areal extent of hail in order to compare storm days, two methods of evaluation were used. A county occurrence evaluation was used, by which hail occurrence in any portion of a county was recorded as a county occurrence. In most instances an entire county was not affected by hail, but this method for describing areal extent of hail was useful because counties represent analytically convenient divisions of Illinois. The second method for evaluating areal extent utilized records from 40 U'. S. Weather Bureau stations in and near Illinois. Each station had reliable hail records for the 1915-50 period, and the number of stations reporting hail on each storm day could be determined for measuring areal extent.

ANALYTICAL RESULTS

Temporal Occurrence

Eighteen severe hailstorm days in the 36-year period were selected to furnish a sample number which would make each storm day equivalent to a 2-year recurrence storm day on the basis of a partial duration series. The actual number of years in which- the 18 storm days occurred was 13. Three storm days occurred in 1948 and in 1925, and two in 1934. The specific dates of occurrence are given in Table 1. Nine of the 18 storm days occurred in July, the month when grain crops in Illinois are normally most susceptible to hail damage.

The time of occurrence and duration of the hailstorms on the 18 storm days also were investigated. On three of the 18 days, hailstorms occurred at two distinctly different times, separated by a period of two hours or more with no hail. Therefore, 21 periods of hail were analyzed as separate time events, and the time analyses were based on these 21 samples.

The 2-hour period when hail formation was most frequent was from 3:00 to 5:00 P.M. CST as 9 of the 21 hail periods were initiated in these two hours. Twenty of the hail periods began in the 11:00 A.M. to

TABLE 1.—Monetary losses and percent of annual farm value lost by damages produced by 18 most severe summer hailstorm days, 1915-50.

Rank	Storm date	Total storm loss, in thousands of dollars, normalized to 1910-14 price indices	% of total storm loss		Total storm crop loss as % of annual farm value
			Crop damages	Property damages	
1	8/17/48	3,173	99.8	0.2	0.26
2	7/28/43	2,719	88.0	12.0	0.31
3	7/22-23/31	665	99.8	0.2	0.38
4	7/10/34	1,152	43.5	56.5	0.20
5	6/20-21/15	399	85.1	14.9	0.08
6	7/13/34	351	98.8	1.2	0.14
7	8/18/25	351	100.0	0.0	0.08
8	7/1-2/33	273	100.0	0 0	0.13
9	6/14/48	503	95.0	5.0	0.04
10	8/29/48	478	100.0	0.0	0.04
11	8/18/46	410	97.6	2.4	0.03
12	8/9/25	265	100.0	0.0	0.06
13	7/24/25	255	98.8	1.2	0.06
14	8/9/32	134	82.2	17.8	0.06
15	7/10/30	112	97.2	2.8	0.04
16	7/25/38	118	76.8	23.2	0.03
17	6/25/44	214	80.9	19.1	0.02
18	7/21/27	116	97.3	2.7	0.03

11:00 P.M. CST period. Hail began at 4:00 A.M. CST in the one exception. The 6-hour period of most frequent hail initiation was 3:00 to 9:00 P.M. CST with 15 of the 21 hail periods beginning in this time period. Lemon (1943) reported that one-third of 2105 damaging hailstorms in the Middle West began in the 2-hour period after 4:00 P.M. CST. Lemon also found that 68% of 2105 damaging hailstorms in the Middle "West began in the 6-hour period beginning at 1:00 P.M. CST.

The average duration of the hail periods was 2.4 hrs. and the median duration was 2.0 hrs. The greatest duration for one storm period was 6.5 hrs. and the shortest duration was 0.4 hrs. There was no correlation between variations in hailstorm duration and amount of damage produced by each storm.

Monetary Losses

Monetary losses produced by the eighteen storm days ranged from a high of $3,172,508 to a low of $112,472, as normalized by 1910-14 price indices. Three storm days each produced more than one million dollars in damage, and 13 had losses in excess of a quarter of a million dollars. The 18 storm days produced a total of $11,687,500 in losses for an average of $649,305. A summary of losses for each storm day, as presented in Table 1, shows that losses from crop damages accounted for a large proportion of

the total loss in most storms. On only one storm day did property damage exceed crop damage, and on four storm days no property losses were recorded.

The right-hand column in Table 1 lists for each storm day the percentage of annual farm value lost because of crop damages (Illinois Agricultural Statistics, 1949). This was the other major factor used in evaluating the storm days and in assigning rank values to them. A wide range exists in, these values (Table 1), from 0.02% up to 0.38% with an average of 0.11 % per storm. These percentages appear to be small in relation to the Illinois farm value in any one year, but for a more realistic present-day impression, a percentage loss in 1954 such as suffered in the July 1931 storm would amount to $4,700,000 in 1954 dollars (Illinois Agricultural Statistics, 1958).

Maximum Hailstone Sizes

The maximum size of hailstones occurring in each of the 18 storm days was expressed in stone diameter. If stones were elliptical, the greatest diameter measurable for the stone was used in this analysis. On all storm days the maximum diameter found exceeded 1 in. The average diameter of the largest hailstones was 1.9 in. The largest hailstones found in any of the storms were 4 in. in diameter and these occurred in the June 1915 storm. In this storm, many cattle and hogs in the open fields were killed by the hail. Three of the other storm days had hailstone data also worthy of mention. The storm of June 14. 1948, produced hail 4 in. deep along a path 4 by 16 mi. with occasional drifts of hailstones up to 4 ft. deep. The storm of August 9, 1925, produced hail to a depth of 3 in. over a path 3 by 24 mi. During the July 10, 1934, storm, slabs of hail the size of coffee saucers were reported. In general, differences in the maximum size of the stones, in the range of 1 to 4 in. in diameter, had no apparent effect on the amount of damage produced by the storms.

Areal Distribution

Hailstorm path sizes. Complete data on all the hail paths which occurred in the 18 storm days were not available. However, sizes of many of the major paths were recorded as to width and length in miles. From the 18 storm days accurate path size data were available for 14 hail paths, and these 14 paths were associated with 15% of the total loss of the 18 storm days. Analysis of the path sizes indicated that the average width was 4 mi. with widths varying from 2 mi. to 10 mi. Lemon (1943) reported that the average path width for 2105 damaging hailstorms in the Middle West was 1.5 mi. The average length of the 14 paths was 18 mi; the shortest path was 8 mi. and the longest path length, 40 mi. The amount of loss associated with a path did not appear to be a function of path length or width.

Number of separate areas of hail in each storm. Areal analysis of the hail reports for the 18 storm days revealed that frequently two or more noncontiguous areas of hail occurred on a storm day. The basis used to define these separate areas

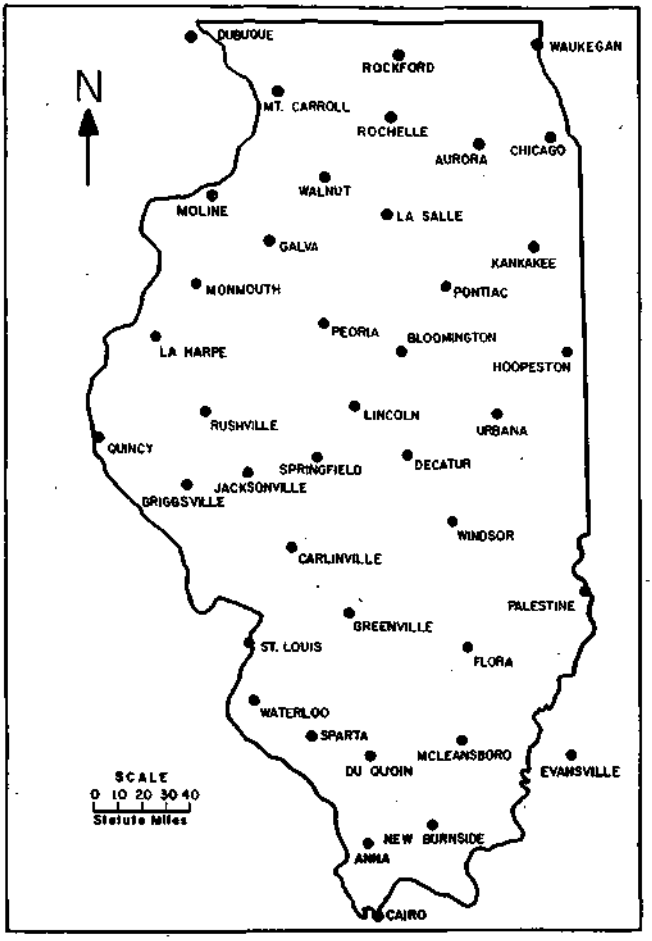

Fig. 1.—Forty U. S. weather stations with reliable hail records in 1915-50.

of hail on a storm date was a distance of at least 40 miles with no hail reports between hail areas. Using this basis, 12 of the storm days had two or more distinct hail areas and seven of these had three hail areas. This analysis indicated that 37 hail areas were produced by the 18 storm days. In general, the severest of the 18 storm days were the days with three or more hail areas.

Number of weather bureau stations reporting Kail in each storm. On eight storm days hail was reported at four or more of the 40 U. S. Weather Bureau stations used in this analysis (Fig. 1). The greatest number of stations reporting hail on any one day was nine on August

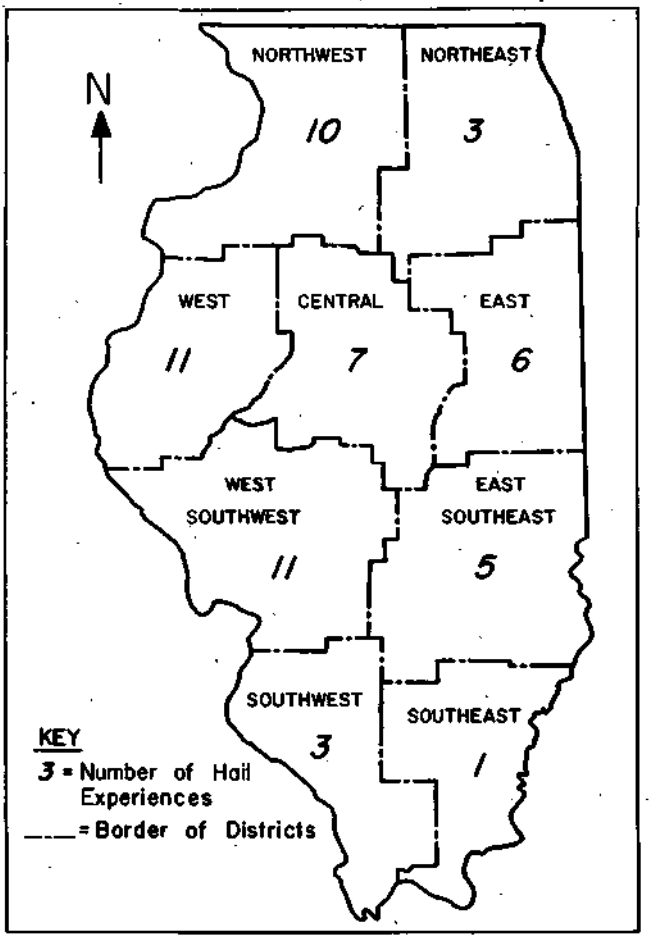

Fig. 2.—Number of times that each crop district was affected by the 18 most severe summer hailstorms.

17, 1948. On a monetary basis, this storm day was classified as the most severe of the 18. -Flora (1956) in his listing of severe Illinois hail storms also classified this hailstorm day as the worst on record in Illi-, nois, although his loss data were not normalized for changing prices. In general, there is a good relationship between the rank or severity of the storms and the number of Weather Bureau stations reporting hail.

Regional and county distributions of hail. From detailed areal plots of hail on each storm day, the number of times each county experienced hail was determined. Utilizing these data, the number of times these 18 storm days produced hail in each

U. S. Weather Bureau crop-reporting district (Illinois Agricultural Statistics, 1958) also was plotted. The areal frequency results for the nine Illinois crop-reporting districts, which are areas of approximately equal size, are shown in Figure 2. Since hailstorms during most of the 18 days affected more than one district, the total number of occurrences was 57, exceeding the number of storm days by a factor of three. Inspection of Figure 2 shows that the upper two-thirds of the western portion of Illinois had the greatest number of experiences with the three westernmost districts having almost equal frequencies. The number of occurrences by districts diminishes rapidly to the south and east from the high incidence region in the west.

To obtain a more detailed description of areal distribution, the number of times each county experienced hail resulting from the 18 storm days was plotted . (Fig. 3). The pattern is similar to that in Figure 2, although the concentration in western Illinois separates, on the county basis, into two distinct areas of most frequent experience. The most prominent area, with four or more experiences, extends northeastward from Adams County for 200 miles into Carroll County. A secondary maximum occurs in three counties: Morgan, Sangamon, and Montgomery. Areas of no experience are shown in portions of northeastern, eastern, and southern Illinois. The general distribution pattern revealed by this map relates well to the average summer hail distribution in Illinois (Huff and Changnon, 1959).

To describe the county distribution of hail damage, the number of times each county experienced hail damage is shown in Figure 4. The pattern is generally similar to that in Figure 3 except that the areal frequency values are lower and the areas of high incidence are smaller. The entire southeastern half of Illinois except for a few isolated areas, had no hail damage. Three counties, Whiteside, Warren, and Hancock, had the greatest frequency of damaging hail experiences.

Synoptic Weather

The type of surface synoptic conditions associated with the occurrence of the 18 hailstorm days was investigated. No analysis of upper-air data was performed due to the lack of these data during most of the 36-year period of study. Analysis of surface weather conditions revealed that four different surface weather types were associated with the hailstorms on the eighteen days. As might be expected, squall lines were the most frequent type of weather associated with hailstorms, eight storm days having squall lines. The number of cold front cases was five with four cases being associated with warm fronts. One hailstorm day was associated with air mass conditions.

Associated Weather Conditions

Severe weather. All but four of the severe storm days had associated reports of high surface winds. Nine of these 14 storm days with high surface winds had wind damages in addition to the hail damages. The

storm of August 17, 1948, had a tornado in addition to high surface wind reports. In several of the storms, damages from lightning were reported. In most instances, these reports of wind and lightning damages were in the area of hail damage. The presence of high wind velocities serves to increase the damage potential from hail.

Rainfall. The daily rainfall pattern associated with each of the 18 storm days was plotted using U. S. Weather Bureau records (1915-51). From these maps, studies of the association of rainfall and hail were made by comparing the location of hail areas with respect to the cores in the daily rainfall pattern, by ascertaining mean daily rainfall values for the hail areas, and by determining the state-wide rank of the highest daily rainfall value found in the hail areas of each storm day.

To ascertain the juxtaposition of the hail area and the rainfall cores, the hail areas were described as being either in or out of a rainfall core. A rainfall core was defined as a region of relatively heavy rainfall having appreciable decreases in rainfall amounts away from the region in two or more directions. As mentioned previously, there were 37 separate areas of hail on the 18 hail days. Thirty-four of these hail areas were found to lie within rainfall cores which indicated that a relationship existed between areas of maximum rainfall and hail incidence areas. A previous study of the relationship of hail occurrences to rainfall cores based on severe spring hailstorm days in Illinois (Huff and Changnon, 1959) indicated that 63% of the hail occurrences were in rainfall cores as compared to 92% in these 18 summer hailstorm days.

To obtain an estimate of the areal significance of the heavy rainfall found within the hail areas, the highest point rainfall value occurring in a hail area for each storm was selected. This value then was compared with all point values in the area of Illinois with no hail occurrences, and the highest hail area value was assigned a rank in relation to all other high values in Illinois. This analysis revealed that, in 13 of the 18 storm days, the highest point rainfall in the hail area ranked either first or second for the entire state on those 13 storm days.

CONCLUSIONS

The 18 most severe summer hailstorm days in the 1915-50 period produced losses which appear large to the average Illinois citizen and farmer, but the actual amount of the Illinois annual farm value destroyed by the most severe hailstorm day was minor, only 0.38 percent of the total. The greatest amount of damage on one storm day, normalized to 1910-14 price indices, was $3,172,508, which occurred on August 17, 1948.

The hailstorms on the 18 days occurred most frequently in the late afternoon and early evening, and the duration of hail averaged 2.4 hrs. No correlation existed between storm duration and amount of monetary loss. Maximum hailstone sizes associated with the extremely severe summer hailstorms were at least 1 in. in diameter, although the amount

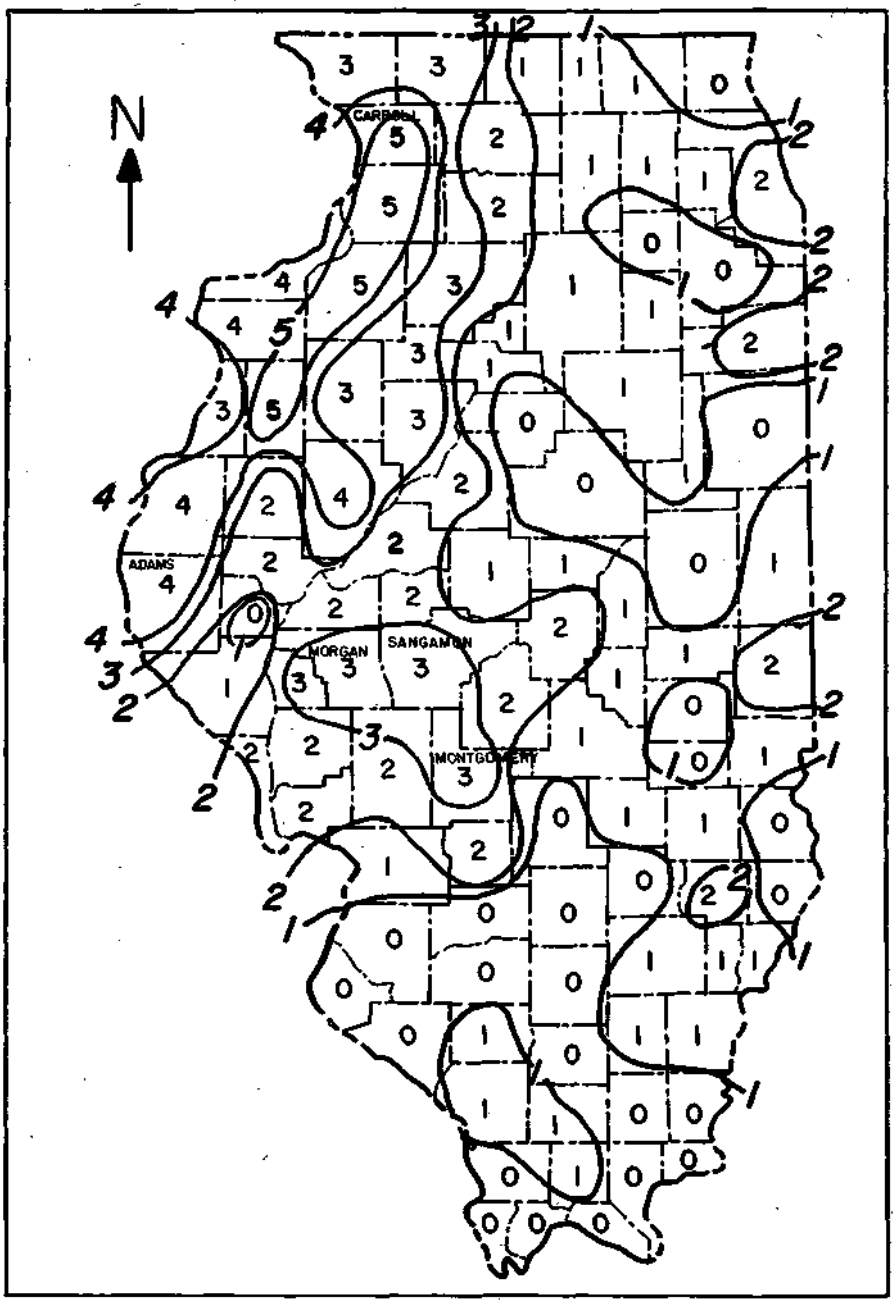

Fig. 3.—Number of times each county experienced hail produced by the 18 most severe storms.

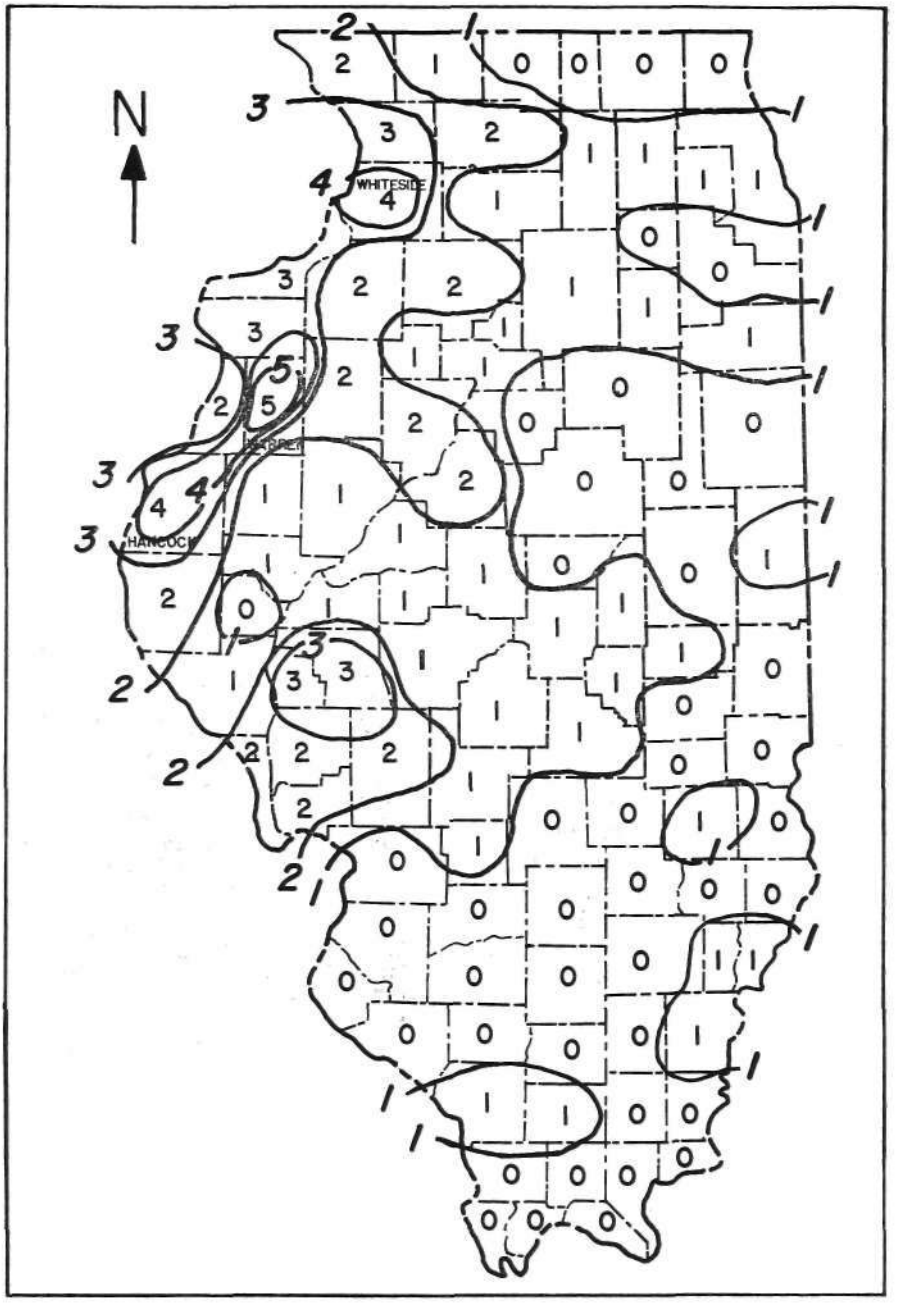

Fig. 4.—Number of times each county experienced hail damage resulting from the 18 most severe hailstorms.

of damage produced by a storm was not a function of maximum stone size, differences occurring in the range from one to four inches in diameter. Path sizes associated with the severe hailstorms varied considerably. The average path width was 4 mi. and the average length was 18 mi. There appeared to be no. relation between the path size and-the amount of damage produced.

Based on the 18 storm days studied, summer hailstorm damage was most frequent in western, northwestern, and southwestern Illinois, and was least frequent in southern Illinois. The areal extent of hail and hail damage varied considerably between storms, and occasionally the damage area was relatively small. However, normally the larger the area of hail, the greater was the damage. Therefore, areal extent of hail appears to be one of the best surface factors correlated with the amount of monetary loss.

The investigation of synoptic weather types associated with the severe summer hailstorms indicated that there was no single weather type which could be considered the predominating cause of these hailstorms. Most of the severe hailstorms were accompanied by high surface winds which increased crop damage from hail. The occurrence of high winds appears to be a second factor correlated well with the amount of damage. The areas of hail were frequently associated with heavy rainfall, often greater than 0.9 inch per day, and 92% of the hail areas were found in the rainfall cores. Frequently, the highest rainfall value in the hail area was the highest in Illinois for that date. However, the extent or intensity of rainfall did not always reflect the amount of hail damage.

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