CHIAA Research Report No. 17

MONTHLY AND SEMI-MONTHLY DISTRIBUTIONS OF HAIL DAYS IN ILLINOIS

by
Stanley A. Changnon, Jr.
Climatologist, Illinois State Water Survey

Crop-Hail Insurance Actuarial Association
209 West Jackson Boulevard
Chicago 6, Illinois

December 30, 1963

MONTHLY AND SEMI-MONTHLY DISTRIBUTIONS OF HAIL DAYS IN ILLINOIS

by

Stanley A. Changnon, Jr.

INTRODUCTION

A detailed analysis of the areal distribution of hail days in Illinois has been performed. Using hail data from 93 U. S. Weather Bureau stations in Illinois, monthly and semi-monthly maps depicting the average number of hail days were prepared. The analysis was performed using hail occurrences recorded in the May 1-October 31 period which largely encompasses the period when crop losses from hail normally occur in Illinois.

Earlier studies by Changnon (1) of the relation between the areal-frequency distribution of hail days and the reported crop losses in Illinois revealed the existence of a strong correlation between these two events. The average summer (June-August) hail day pattern in Illinois (2) was used by the Crop-Hail Insurance Actuarial Association to aid in the establishment of regional variations in the hail insurance rates for Illinois.

The present study serves as an extension and enlargement of the previous studies. Since most principal insured crops in Illinois have one or two rather distinct and often short periods of maximum susceptibility to hail damage, it was decided to map the hail-day patterns for periods which were considerably shorter than the 3-month summer season. Areal variations of hail days for specific periods of maximum crop risk should be a more

accurate means of ascertaining regional variations in risk and rating for individual crops. To this end, the hail data from the 93 stations in Illinois with accurate hail records were analyzed to compute monthly and semi-monthly hail-day averages.

Data used in this analysis were principally from 65 of these stations which had 20 years or longer accurate hail records within the 1901-1962 period. Data from the remaining 28 stations with good hail records for periods of 10 to 19 years duration were also analyzed, but these data were not assigned equal analytical value to those averages based on the longer records. A previous study of long-term Illinois hail data revealed that point averages of hail days based on 20 years or more data eliminated most significant variations and furnished rather reliable estimates of the true average (2). The 28 shorter-period point averages were used as guides in fixing the more minor features of the hail patterns, whereas the major features of the patterns were based on the data from the 65 stations with long records. In order to present all values as whole numbers, all averages were expressed as the number of hail days in an average 20-year period.

The results of this study provided certain interesting and significant findings. The semi-monthly patterns of hail days often varied in consecutive periods. Although the patterns in some consecutive periods varied to a large degree, there were individual areas of higher incidence which appeared in the same general location in most of the semi-monthly periods.

The September 1-16 period, rather than those in October, was found to be the period of least general incidence in Illinois. The May 1-15 period had the highest semi-monthly average number of hail days in southern Illinois, whereas the May 16-31 or June 1-15 periods had the highest averages in the northern half of Illinois. In the May-October period, May was the month of maximum hail incidence in most parts of the state, and October was the month with the lowest hail frequency throughout most of Illinois.

MAY-OCTOBER HAIL DAY DISTRIBUTION

The distribution of hail days in Illinois for the May-October period is shown in figure 1. Also shown are the locations of the 93 stations with hail data. On figure 1 the major areas of high and low incidence are labeled H and L, respectively.

Among the major features shown on figure 1 is the ridge of high incidence extending southeastwards from Pike County to Wayne County. The position of this ridge is in and just north of a ridge in the May-October frontal frequency pattern for Illinois (3). As shown in figures 2 and 3, a ridge in this area is found in the frontal frequency patterns for both stationary and cold fronts. The ridge in the stationary frontal pattern (figure 2) is most closely aligned with the ridge in the hail pattern. In a previous hail study, Huff found that the summer areal distribution of stationary fronts correlated well with the summer (June-August) hail pattern (4). The alignment between the ridges shown in figures 2 and 3 and the ridge in figure 1 strongly suggests that this major feature of the hail pattern

is a result of these macro-scale synoptic weather features.

The localized high incidence area of hail in extreme southern Illinois (figure 1), as will be shown in later portions of this report, is largely a result of a high number of hail incidences during May and June. The effect of the local hills and the relatively rough terrain in this area probably are the major causes of the greater number of hail days in this area than in surrounding areas. No features in the climatological distributions of fronts appear to explain this high.

The third major feature shown in figure 1 is the high incidence area in east-central Illinois. The climatological distribution of cold fronts shown in figure 3 for the May-October period has an area of relatively high frequenceis in the same specific area. This suggests that this high is a result of the greater cold frontal frequencies shown for this area.

The fourth major feature shown on figure 1 is the small area of high incidence centered in McDonough County in western Illinois. This particular area has the highest average number of hail days found anywhere in Illinois during the May-October period. Examination of figure 3 reveals that in the 1945-59 period this area experienced relatively more cold fronts than nearby areas to the south, east, and north. This area also had 25 percent more warm front occurrences than did Adams or Knox counties.

The fifth major high incidence area in the May-October hail pattern occurs in northwestern Illinois. Inspection of the cold front distribution (figure 3) reveals that a high incidence area also appears in this same area. Thus, this area appears to be a result of macro-scale synoptic weather

conditions.

MONTHLY HAIL DAY DISTRIBUTIONS

The distribution of hail days in each of the six months in the May-October period is shown in figures 4-9. In most areas of Illinois, May (figure 4) has higher averages than any of the other five months. The areas where the May averages do not predominate occur primarily in south-central Illinois. Comparison of figures 4 and 5 reveals that portions of Pike, Wayne, Clay, Marion, Bond, and Fayette counties experience hail more frequently in June than in May. In south-central Illinois the June pattern of hail days is considerably different than the May pattern. The most predominant high incidence area in May in Illinois is located in the extreme southern portion (figure 4), whereas in June the predominant statewide high is located in the south-central region (figure 5).

The number of hail days in most state locations in July (figure 6) is about 50 percent lower than the number in June. All but one of the major high incidence areas shown for June appear on the July map. The high in extreme southern Illinois apparent in the May and June maps is not apparent in July. The principal area of maximum hail incidence in July is centered in east-central Illinois, a more northward location than in May and June. .

In all of Illinois except the extreme western and northwestern portions, the average number of hail days in August (figure 7) is not significantly different than the number in July. However, in August the high incidence areas in western and northwestern Illinois have a greater

number of hail days than they did in July. The predominant statewide high incidence area is located in northwestern Illinois in August. However, a very small area with a slightly higher average does occur in western Illinois.

The average number of hail days in all parts of the state in September (figure 8) is lower than the average for August. The area of high hail averages centered in Macoupin County in September dominates the state pattern. Smaller highs still persist in northwestern and east-central Illinois, and the high in southeastern Illinois has reappeared in September after being absent in the August pattern.

In most portions of Illinois, October (figure 9) on the average has fewer hail days than occur in September. The predominant area of hail activity in October is an east-west oriented ridge across south-central Illinois.

SEMI-MONTHLY HAIL DAY DISTRIBUTIONS

The semi-monthly hail-day analysis was performed by dividing each of the six months between the 15th and 16th dates of the month. Thus, averages and maps for a total of 12 semi monthly periods were prepared. The maps depicting these hail-day patterns are shown in figures 10-21. The discussion of the results of this phase of the analysis is restricted to certain pertinent finds and selected features appearing on the mapped patterns. Suggestions are also offered as to the use of these data in determining variations in crop risk.

Semi-Monthly Hail Patterns

In the May 1-15 period (figure 10) the state pattern displays considerable areal variability, especially in central Illinois. The highest averages occurred in McLean and Henderson counties. Average values in most of the area south of a line from Calhoun County to Vermilion County are higher than those in any of the other 11 semi-monthly periods. The great areal variability in this period and in most of the following 11 periods is in direct contrast to semi-monthly hail-day patterns appearing in an earlier study by Lemons (5). Lemons employed data from the Weather Bureau first-order stations in the United States, and there are only 10 such stations in and adjacent to Illinois. His semi-monthly maps showed no regional variability in hail days throughout Illinois except during the last three semi-monthly periods of the May-October period. His maps are not in error for the data employed, but the difference between his findings and these on areal variability of hail reveals the degree of inaccuracy in areal descriptions of hail days which will result when too few locations are used to define the hail pattern.

The succeeding period, May 16-31 (figure 11), also has a highly variable pattern which differs considerably from the pattern of early May. The predominant feature of the May 16-31 pattern is the adjacent high and low area which extends across central Illinois. The largest area of high hail incidence is located in southeastern Illinois. In most of central and northern Illinois the average number of hail days in this second period of May is higher than those in the other 11 periods.

The hail-day pattern for the first period of June (figure 12) is somewhat similar to the May 16-31 pattern, especially in the southern half of the state. A small but significant high incidence area appears in Pike County, and a major high extends southeast from Sangamon County to Wabash County. In this period, a small high still appears in the hill area of extreme southern Illinois. The average number of hail days in a small portion of western Illinois (Henderson, Warren, McDonough, and Hancock counties) is higher in the June 1-15 period than this area's averages in any of the other 11 periods.

The pattern for the period of June 16-30 (figure 13) shows a slight reduction in the average values throughout most of the state. The high in the south-central region is the predominant feature of this pattern.

The July 1-15 period (figure 14) has values which represent a considerable statewide reduction from the average number of hail days in the latter half of June. The only area which has averages greater than those in the previous period (June 16-30) is located in east-central Illinois. This diminishing of average values with time continues during the second half of July. The July 16-31 pattern (figure 15) reveals the existence of values lower than those of July 1-15 in all areas of the state except northwestern Illinois. The high centered in Carroll County (figure 14) is larger in the July 16-31 period, and a new high is evident in Henry and Knox counties.

The incidence of hail in the first half of August (figure 16) is somewhat greater than it is in the last 16 days of July. The average number of hail

days increased noticeably in the southern half of Illinois. The high area noted in Henry County in the July 16-31 period is still present, and new high incidence areas have appeared in western, eastern, and southwestern Illinois.

A general reduction in the average number of hail days occurred in the August 16-31 period, but most highs apparent in the first half of August are still present. The small high in Henry County (figure 17) is joined with the high in northwestern Illinois to form a larger and more significant high incidence area.

A considerable decrease in hail day activity occurs between the August 16-31 period (figure 17) and the September 1-15 period (figure 18). In many parts of the state, the September 1-15 averages are more than 50 percent lower than the August 16-31 averages, and are also lower than those of the other 11 periods. The high in southwestern Illinois has become the dominant high with low averages along the eastern Illinois border.

The second half of September (figure 19) has a greater average number of hail days than does the first half of the month. The September 16-30 pattern has a notable ridge in hail days which extends from southwestern Illinois across the east-central part, and the high areas in northwestern and southeastern Illinois are enlarged. Portions of southern Illinois have lower averages during the September 16-30 period than they had in the first half of the month.

The hail-day pattern for the October 1-15 period (figure 20) differs considerably from that in the preceding period. The high in southeastern

Illinois has become the dominant one in the state, and a new high is apparent in northeastern Illinois. A trough of hail activity extends from the northwest to the east-central part of the state.

In the second October period (figure 21) the frequency of hail diminishes in all but the northeastern parts. The high frequency area in northeastern Illinois persists throughout October. The pattern of hail days in southern Illinois in the October 16-31 period is not too variable.

Location of Major High Incidence Areas

Inspection of the 12 semi-monthly maps of hail incidence revealed the presence of five major high incidence areas which persisted in the same general locations. The positions of the central areas of these five high hail incidence regions are portrayed on figure 22.

The Northwest high first appears in the May 16-31 period. After diminishing in size in the June 1-15 period (figure 12), this high enlarges and extends to the southeast (figure 13). In the four periods between July 1 and August 31 this high assumes an elongated shape oriented WSW-ENE rather than WNW-ESE as it was during May and June. This high is apparent in the two September periods although its central area (figure 22) is located farther south. This high is not present in the two October periods.

The West high (figure 22) occurs in the four periods from May 1 through June 30 with very little change in position. In the May 16-31 period (figure 11) it is joined with the Southwest high. The West high does not appear in the two July periods, but it does reappear in August, still centered

in McDonough County. The high is not apparent in the patterns for the two September periods, but again reappears in the October periods, although it is then of minor consequence (figures 20 and 21).

The Southwest high is centered in Pike County (figure 22) in many of the 12 semi-monthly periods. In several periods (figures 12, 14, 16, and 20) this high area is a portion of a ridge connected with the Southeast high. In a previous study of Missouri and Iowa hail patterns, Changnon (6) revealed that this Southwest high was a continuation of a high extending across portions of Iowa and Missouri, as were also the West and Northwest highs. The Southwest high is present in all 12 of the semi-monthly periods. The position of the central area (figure 22) in the July 1-15 and the September 16-30 periods is more southerly than it is in the other 10 periods.

The East high is the only other high which is present in all 12 periods. The position of the central area varies considerably within a 9-county area in east-central Illinois. It is displaced southward (Edgar County) in the June 1-15 period, and its position then gradually progresses northward in the three succeeding periods.

The fifth major high occurs in southeastern Illinois. This Southeast high (figure 22) first appears in the May 16-31 period. Its shape and position shift, but generally it is elongated east-west and is frequently centered in and around Wayne County. After an absence in the August 16-31 period, this high reappears in somewhat more southerly positions in the two September periods.

Combination of Periods

To employ the semi-monthly hail patterns in the evaluation of regional and seasonal hail hazards, various periods can be combined to produce patterns for specific types of risks. For instance, assume that a crop grown in central Illinois is most susceptible to hail damage during two separate periods. These periods might be May 16-31 and July 16-31. The hail patterns in central Illinois for these two periods (Figures 11 and 15) could be overlayed and all intercept points of the iso-hail lines could be combined to produce a' special hail pattern. As an example, in central Champaign County a hail-day value of 4 shown on figure 11 would intercept a value of 2 on figure 15, producing a combined value of 6. Similarly, a combined value in northern Champaign County would be 8 hail days. If the same crop grown in northern Illinois had the normal latitudinal delay in crop development, it would have a delay in the hail-susceptibility periods. Therefore, in the northern part of the state one might combine the patterns for June 1-15 and August 1-15 periods for this theoretical crop. In such a manner the intercept method could be employed to combine two, three, or more periods.

SUMMARY AND CONCLUSIONS

All but one of the five major areas of high hail incidence in Illinois shown for the May-October period occur in or immediately adjacent to areas where stationary fronts and/or cold fronts tend to be most frequent in Illinois. This strongly suggests that these high occurrences in the Illinois hail pattern are a result of macro-scale synoptic weather factors rather than localized factors such as terrain roughness or elevation. This is supported

by the fact that an earlier study of the hail patterns in Illinois, Iowa, and Missouri revealed that three of these high hail areas in Illinois extended westward across Iowa and Missouri.

During the May-October period, May on the average is the month with the greatest number of hail occurrences in Illinois. June has a slightly lower frequency of hail days, and the July number is about 50percent lower than the June number in most parts of the state. The number and distribution of hail days in August is not significantly different from that in July. The number of hail days in Illinois diminish through September and October with October having the lowest averages of the 6-month period. The position of the maximum area of hail activity in Illinois varies from month-to-month displaying a latitudinal variation with time. The predominant state high is located in extreme southern Illinois in May and advances northward in June, July, and August. Its position in August is in extreme northwestern Illinois, but by October the position of the high has retreated to south-central Illinois.

The hail patterns of consecutive semi-monthly periods exhibit considerable difference, and large areal variability exists in the hail patterns of all 12 periods between May 1 and October 31. In the southern half of Illinois the period with the highest average number of hail days is May 1-15. Most of the northern half of the state has the highest average number of hail days in the May 16-31 period. In much of Illinois the lowest averages are in the September 1-15 period. Five separate high hail incidence

areas persist in the same general location during many of the 12 periods. These highs are located in the northwestern, western, southwestern, eastern, and southern parts of Illinois. The highs in southwestern and eastern Illinois are present in all of the 12 semi-monthly periods.

To evaluate hail hazards for crops with two or more separate periods of maximum risk, the semi-monthly hail patterns can be combined by the intercept method to produce hail patterns for specific risks. These can be varied regionally to adjust for seasonal variations in the stages of crop growth. The great area variation shown by the semi-monthly hail patterns and the great degree of change between patterns of consecutive periods are indicative of the great spatial and temporal variations that exist in the hail hazard in Illinois.

REFERENCES

1. Changnon, S. A., 1960. Relations Between Annual Hail Loss Cost Insurance Data and Climatological Hail Data. CHIAA Research Report 3, Chicago, Illinois.

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

3. Chiang, I. M., 1961. An Analysis of Selected Synoptic Elements of the Climatology of Illinois. Masters Thesis, Southern Illinois University, Carbondale, Illinois.

4. Huff, F. A., 1961. Correlation Between Summer Hail Patterns in Illinois and Associated Climatological Events. CHIAA Research Report 10, Chicago, Illinois.

5. Lemons, H., July 1943. Semi-monthly Distribution of Hail in the United States. Monthly Weather Review, Vol. 71, No. 7, 119-122.

6. Changnon, S. A., 1961. Annual and Seasonal Average Hail Days Distribution in Illinois, Missouri, and Iowa. Appendix A, CHIAA Research Report 11, Chicago, Illinois.

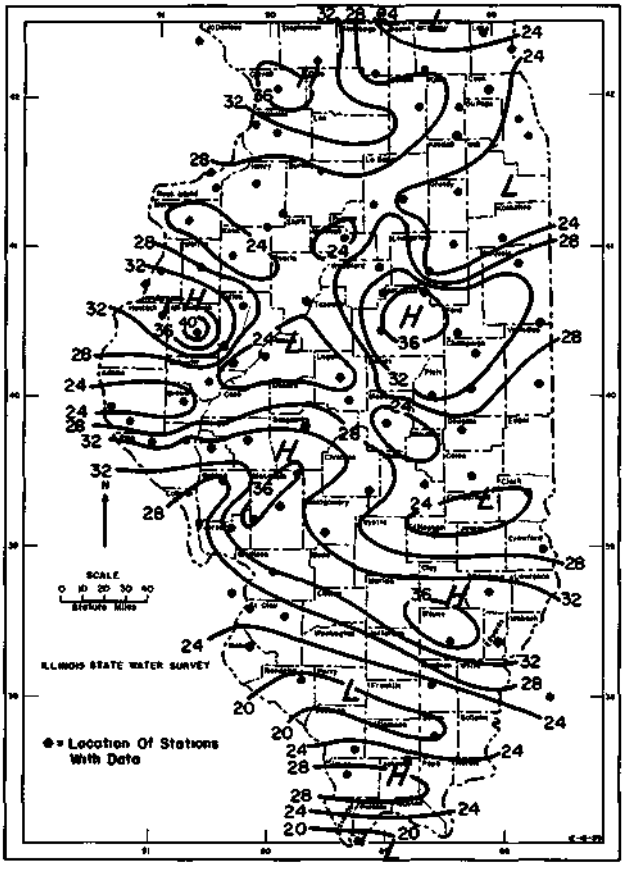

FIG. 1 NUMBER OF HAIL DAYS DURING MAY-OCTOBER PERIOD IN AN AVERAGE 20-YEAR PERIOD.

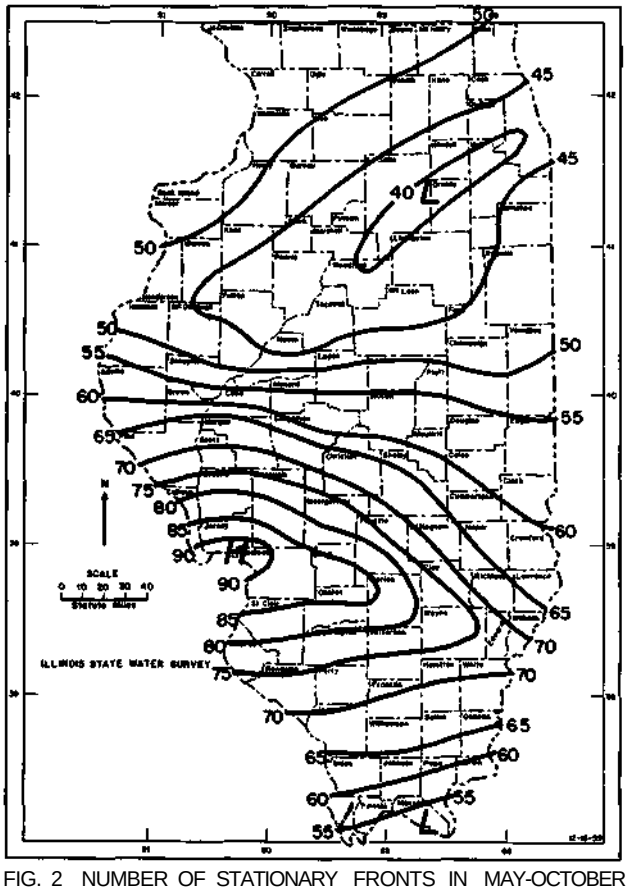

FIG. 2 NUMBER OF STATIONARY FRONTS IN MAY-OCTOBER PERIOD AT 2400 CST DURING 1945-1959

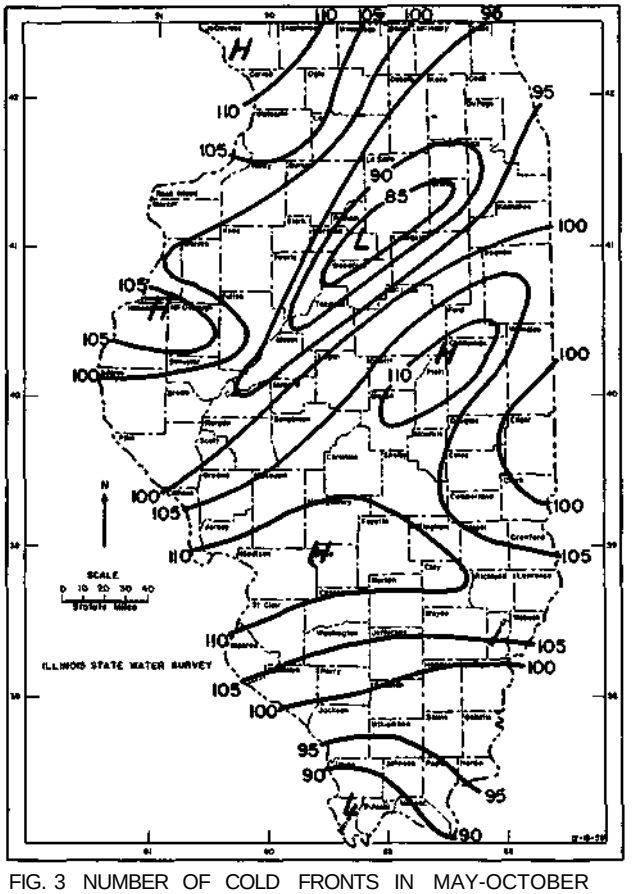

FIG. 3 NUMBER OF COLD FRONTS IN MAY-OCTOBER PERIOD AT 2400 CST DURING 1945-059

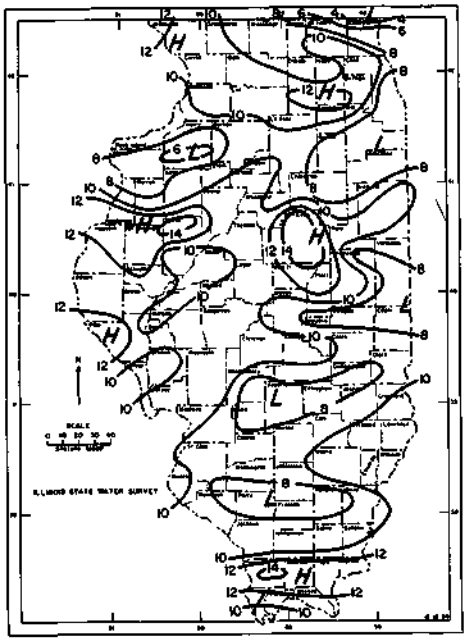

FIG 4 NUMBER OF HAIL DAYS DURING MAY IN AN AVERAGE 20-YEAR PERIOD

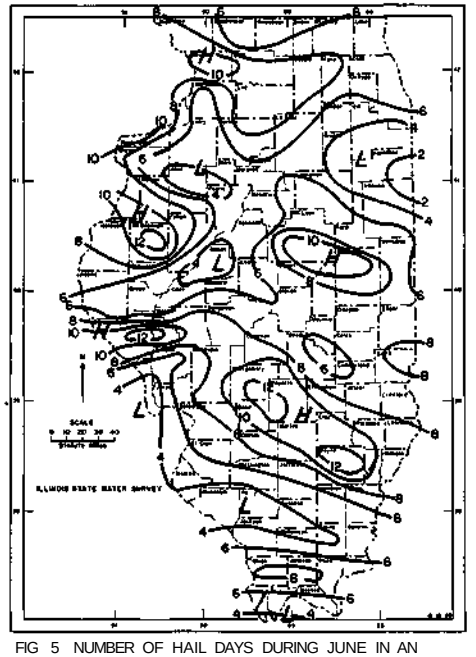

FIG 5 NUMBER OF HAIL DAYS DURING JUNE IN AN AVERAGE 20-YEAR PERIOD

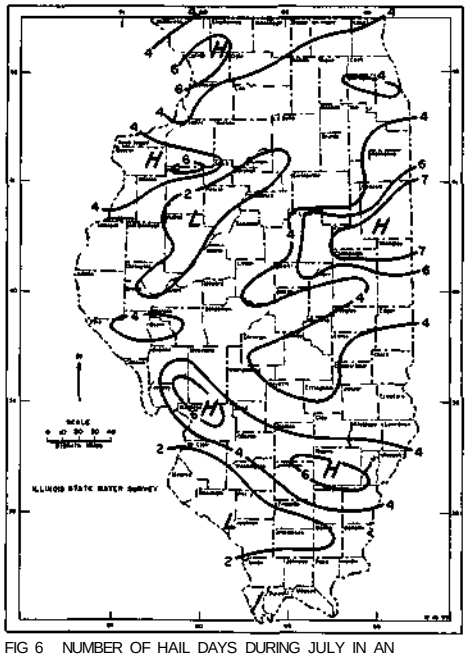

FIG 6 NUMBER OF HAIL DAYS DURING JULY IN AN AVERAGE 20-YEAR PERIOD

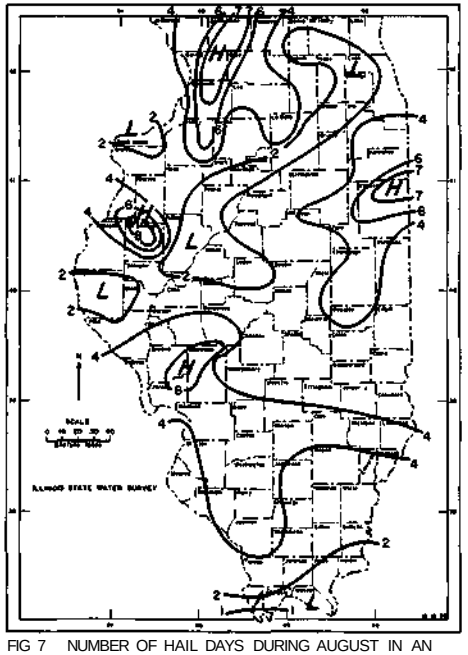

FIG 7 NUMBER OF HAIL DAYS DURING AUGUST IN AN AVERAGE 20-YEAR PERIOD

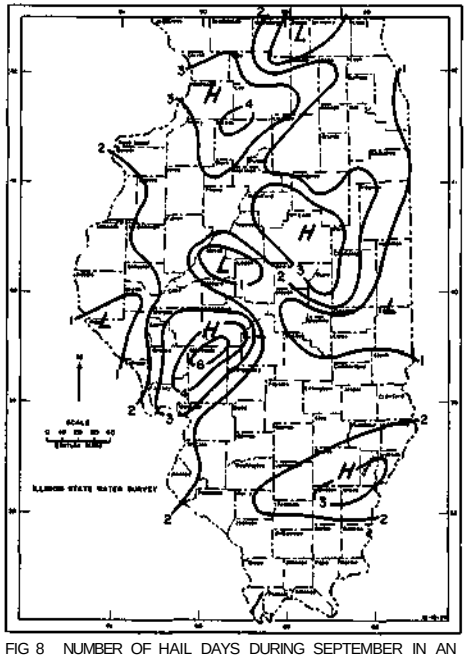

FIG 8 NUMBER OF HAIL DAYS DURING SEPTEMBER IN AN AVERAGE 20-YEAR PERIOD.

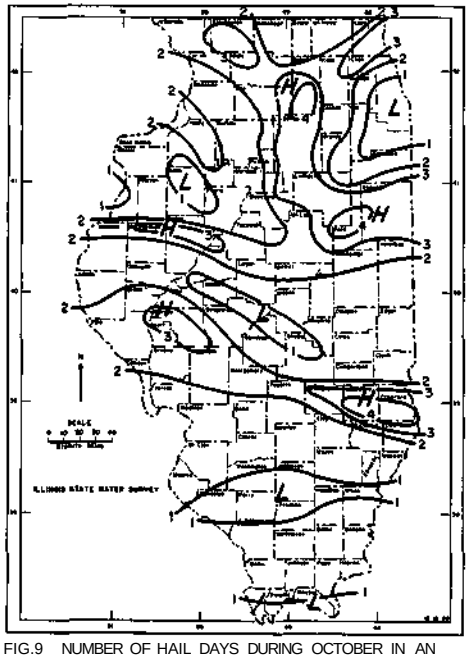

FIG.9 NUMBER OF HAIL DAYS DURING OCTOBER IN AN AVERAGE 20-YEAR PERIOD.

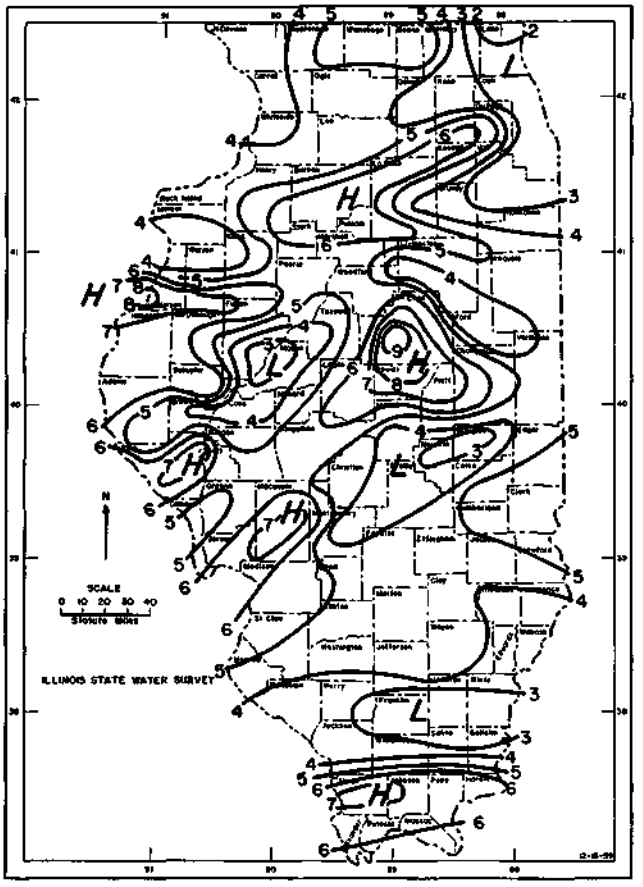

FIG. 10 NUMBER OF HAIL DAYS DURING MAY 1-15 PERIOD IN AN AVERAGE 20-YEAR PERIOD.

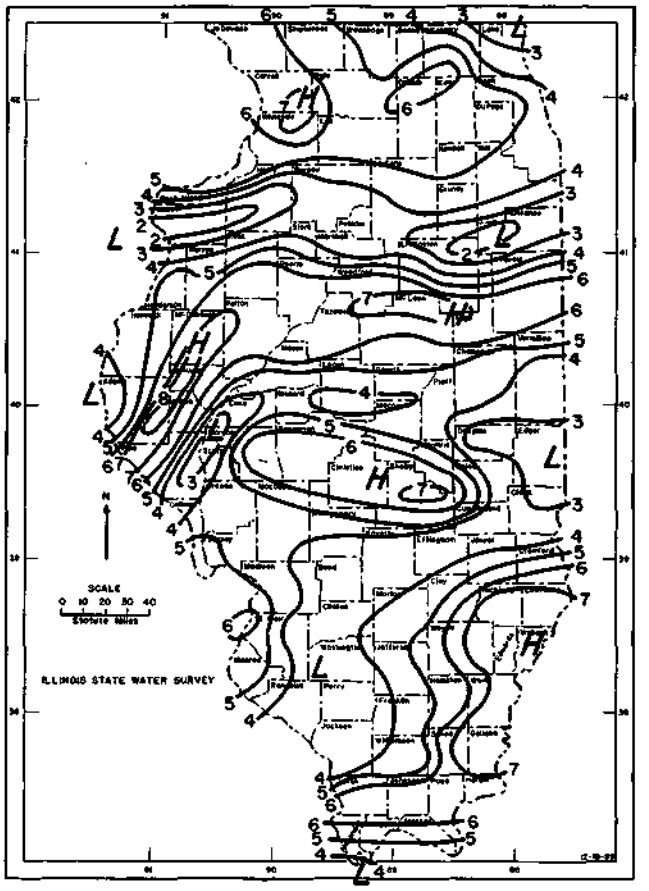

FIG.11 NUMBER OF HAIL DAYS DURING MAY 16-31 PERIOD IN AN AVERAGE 20-YEAR PERIOD.

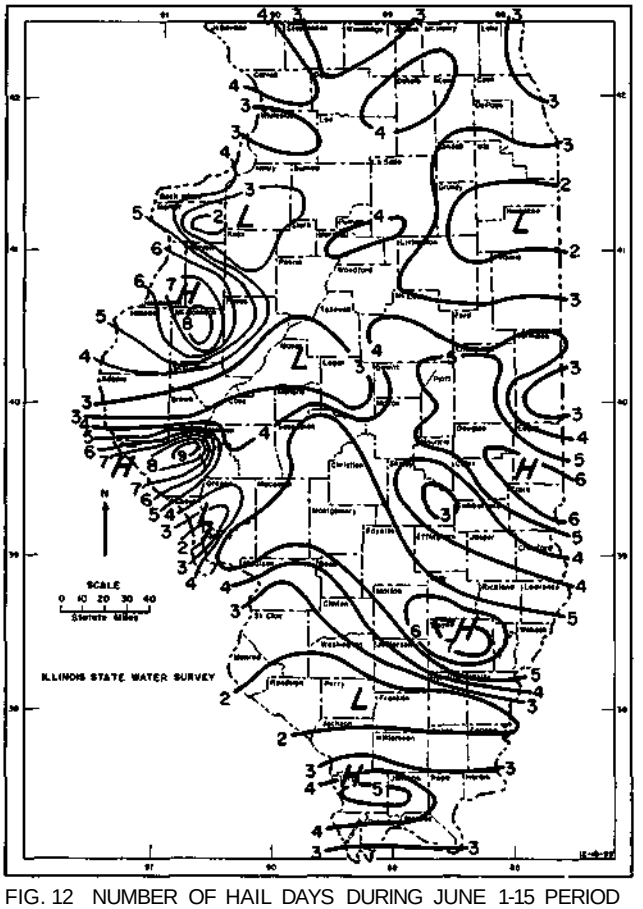

FIG. 12 NUMBER OF HAIL DAYS DURING JUNE 1-15 PERIOD IN AN AVERAGE 20-YEAR PERIOD.

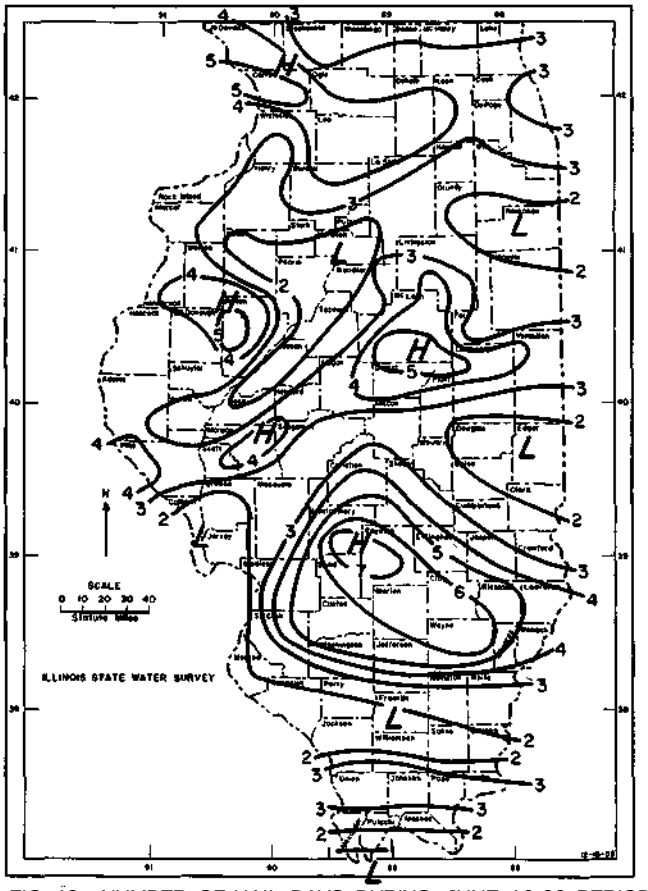

FIG. 13 NUMBER OF HAIL DAYS DURING JUNE 16-30 PERIOD IN AN AVERAGE 20-YEAR PERIOD.

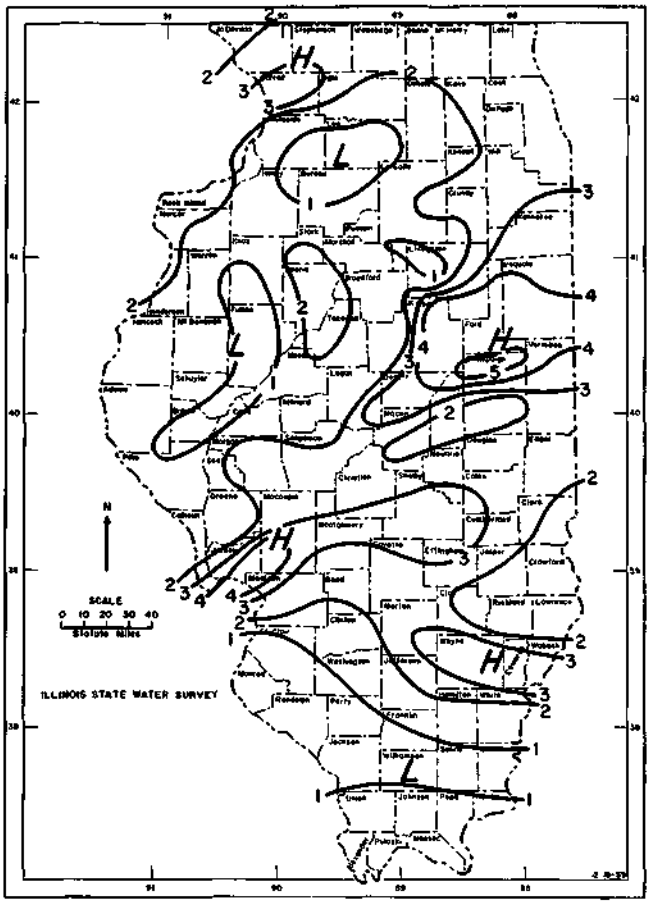

FIG. 14 NUMBER OF HAIL DAYS DURING JULY 1-15 PERIOD IN AN AVERAGE 20-YEAR PERIOD

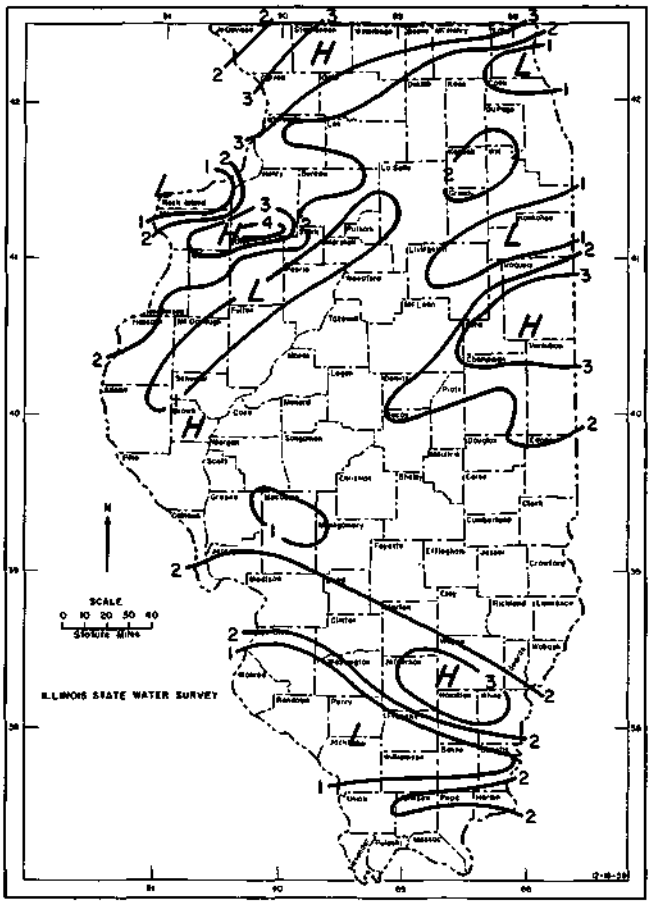

FIG. 15 NUMBER OF HAIL DAYS DURING JULY 16-31 PERIOD IN AN AVERAGE 20-YEAR PERIOD.

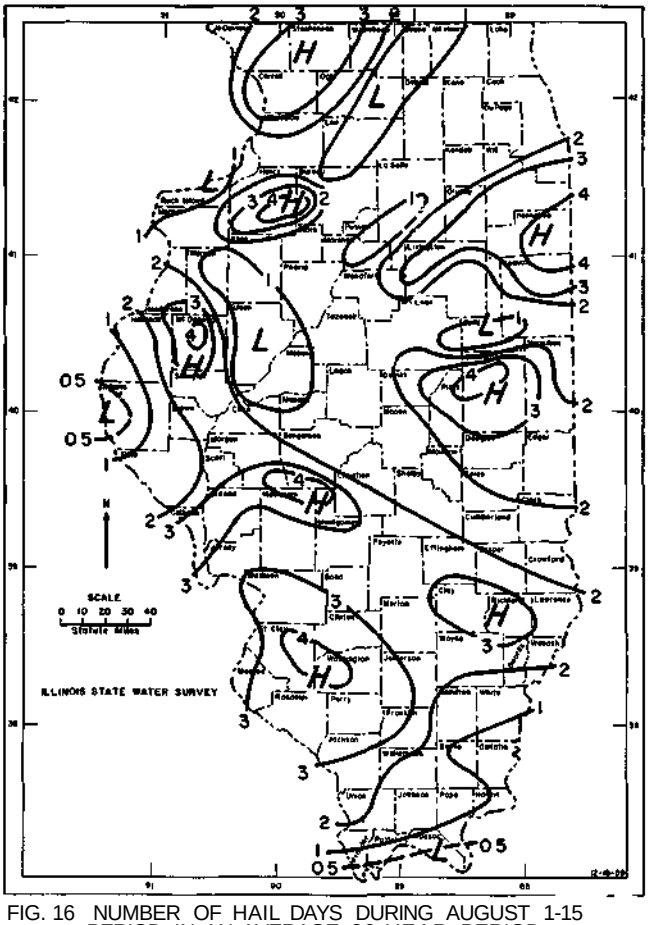

FIG. 16 NUMBER OF HAIL DAYS DURING AUGUST 1-15 PERIOD IN AN AVERAGE 20-YEAR PERIOD.

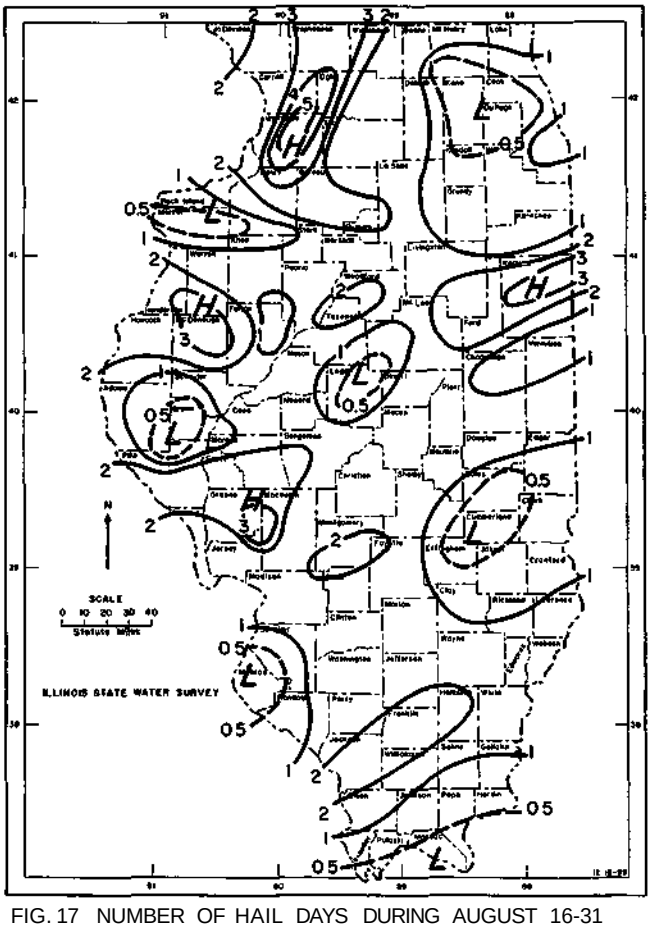

FIG. 17 NUMBER OF HAIL DAYS DURING AUGUST 16-31 PERIOD IN AN AVERAGE 20-YEAR PERIOD.

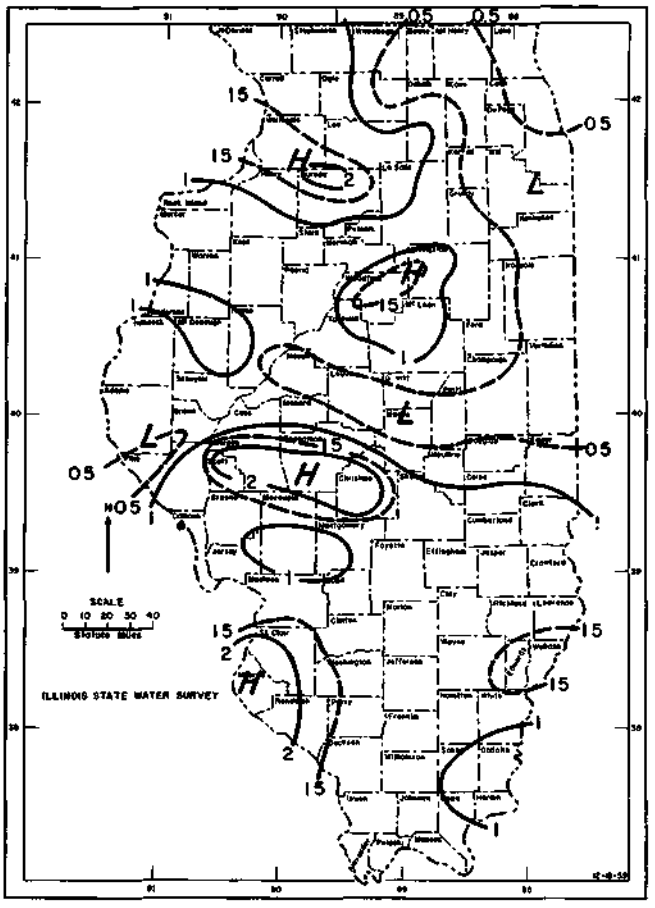

FIG. 18 NUMBER OF HAIL DAYS DURING SEPTEMBER 1-15 PERIOD IN AN AVERAGE 20-YEAR PERIOD.

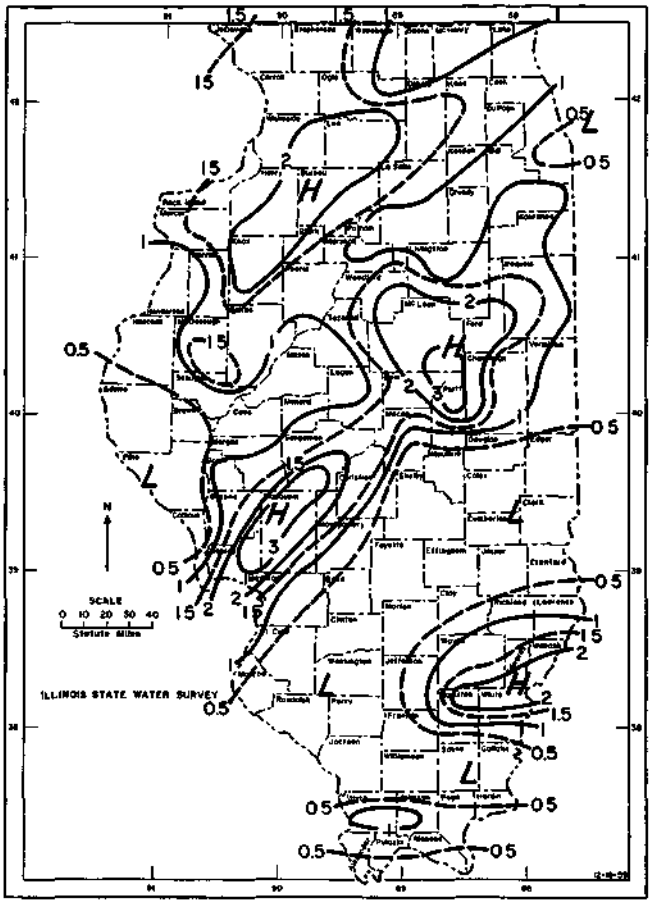

FIG. 19 NUMBER OF HAIL DAYS DURING SEPTEMBER 16-30 PERIOD IN AN AVERAGE 20-YEAR PERIOD.

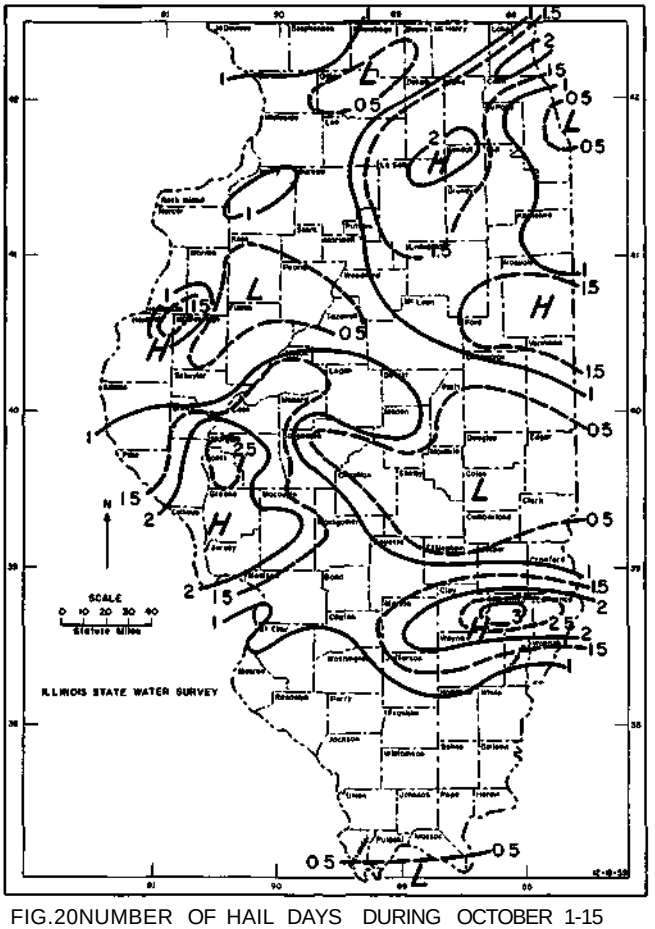

FIG.20NUMBER OF HAIL DAYS DURING OCTOBER 1-15 PERIOD IN AN AVERAGE 20-YEAR PERIOD

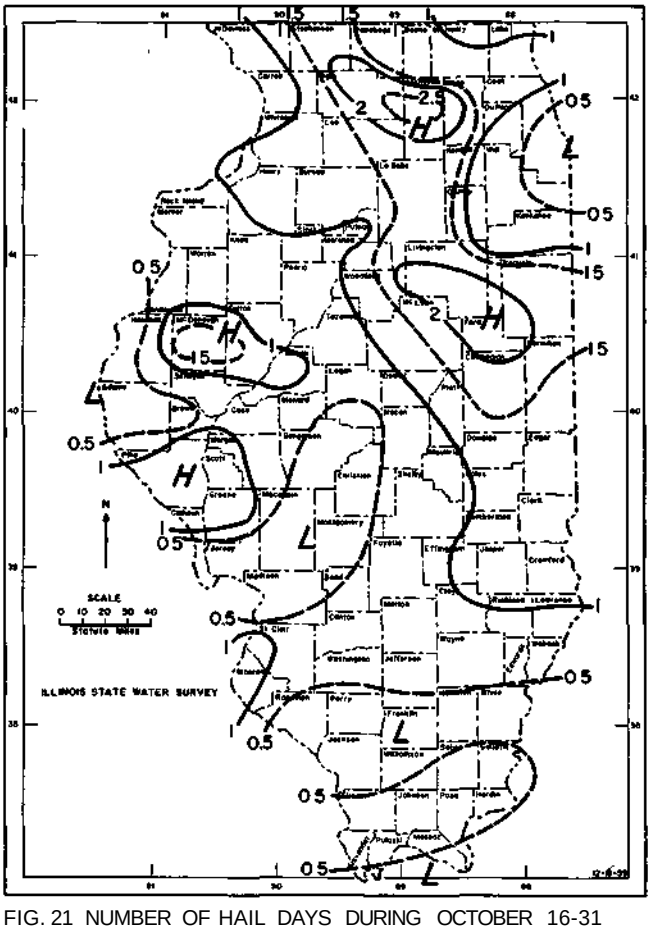

FIG. 21 NUMBER OF HAIL DAYS DURING OCTOBER 16-31 PERIOD IN AN AVERAGE 20-YEAR PERIOD.

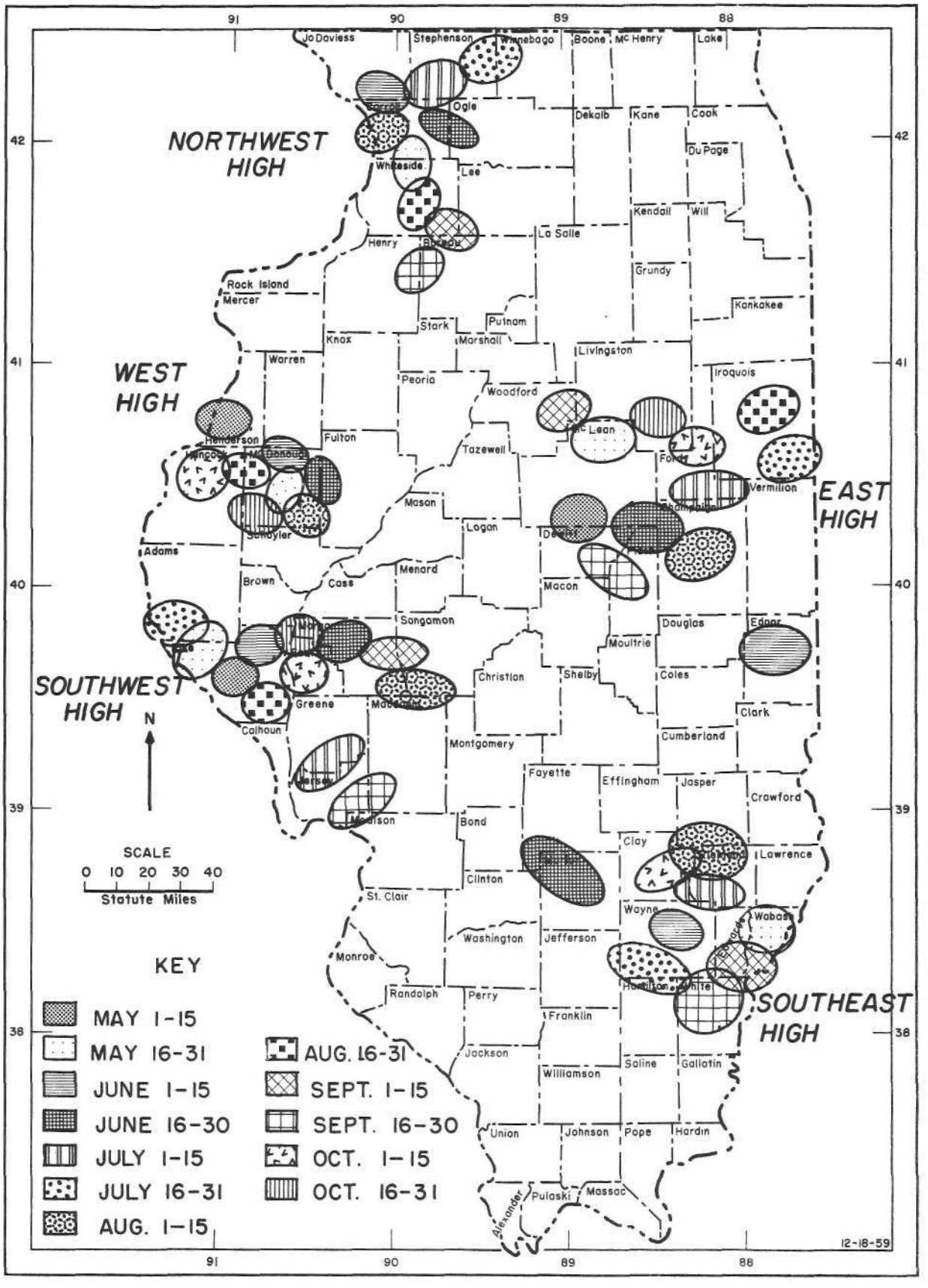

FIG. 22 CENTRAL PORTIONS OF THE PRINCIPAL HIGH HAIL INCIDENCE AREAS OF SEMI-MONTHLY PERIODS