Examples of Economic Losses from Hail in the United States

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ABSTRACT

Crop-hail insurance companies, both private and governmental, insure about 15% of the national crop value, and their data represent a better source of information to evaluate economic aspects of hail loss than exist for any other form of severe weather. Past results and these insurance data were used 1) to illustrate variations in hail losses on various time and space scales, and 2) to reveal through these illustrations the limitations in the available information and the need to make estimates to derive total hail loss for any period or place. The nation's greatest hail loss area is the Great Plains ($86 million annually) with the Corn Belt area ranking second ($67 million). Illinois ranks first in the amount of liability; North Carolina ranks first in total insurance premiums and in number of paid losses; Idaho first in the average amount paid for an individual loss; and North Dakota first in total crop loss. Little information exists about property losses from hail, but limited Illinois studies suggest it represents about 10% of the crop losses. Catastrophic hailstorm loss days that create $1 to $5 million in losses and thus 15–75% of the total annual loss in a state are a major problem for farmers, hail insurance companies, and hail modification groups. The total estimated average annual crop-hail loss in the United States is $284 million, which represents about 1% of the national crop production, and the total national loss (crops and property) due to hail is estimated to be $315 million.

1. Introduction

An accurate assessment of the economic loss produced by various forms of severe weather cannot be performed because of the lack of adequate past records. Thus, the amount of economic loss from any one form of severe weather can only be estimated using data consisting of crude approximations for most forms of severe weather (Maunder, 1970).

The only type of severe weather that has a reasonably large volume of specific quality loss data is hail. This results because crop-hail insurance companies, many of whom have been in existence for 40 years, have kept detailed hail loss records, whereas companies insuring against property damage from hail, tornadoes, winds, rain and lightning, have never identified losses by the causative weather condition. Although crop-hail losses are better defined than any other severe weather loss in the United States, it should be realized that more than 80% of the crop value in the country is not insured, and hence total loss from hail can only be estimated from the insurance data.

The first attempt at some assessment of hail loss in the United States was by Lemons (1942) who estimated that the mean annual crop losses to hail amount to $100 million. Extended coverage losses which include property losses by most forms of severe weather (hail, winds, tropical storms, rain, tornadoes) exceeded $1 billion per year in the United States in the 1953–62 period (Collins and Howe, 1964). Interestingly, no comprehensive studies of hail loss have ever been conducted.

Even though the amount of loss produced by hail in the United States requires estimations, it does have a better data base than other forms of severe weather, and it is extremely important to estimate hail loss because of its importance to the business and scientific communities. For instance, proper insurance rating should be based on comprehensive loss data, and values of loss should be used in helping to set national meteorological research priorities dealing with severe weather.

Assessment of economic loss for various other forms of severe weather has largely been neglected because of the lack of extensive specific loss records kept either by commercial interests or any governmental agencies. Records comprising gross approximations of individual storm losses have been kept by NOAA, and assessments of severe weather losses using these approximations (Sanders, 1971) must be treated with great caution. In a few states, such as Illinois, past state climatologists or their predecessors took it upon themselves to gather fairly detailed weather loss records during periods of their service, but in many states no such quality weather loss records exist.

This paper presents examples of the economic aspects of hail loss on both a spatial (local, state, and national scale) basis and a temporal basis (daily and yearly). The results presented are based largely on either readily accessible loss data or on information in earlier loss studies.

The purposes of the paper are to illustrate: 1) what is known and can be determined about hail loss on various space and time scales; 2) the limitations, including the availability, source and evaluation, of existing hail loss data; 3) the types and magnitudes of estimations required to derive total loss or values; and 4) the magnitude of hail loss using limited but accurate loss data and comparison with loss from other severe storms and to losses from other longer-term (seasonal) weather extremes exchange. A comparison of hail-produced crop losses and property losses, based on two Illinois studies, is presented primarily to derive a ratio of crop to property loss, and this ratio is used in estimating the total national hail loss. Other material presented include state averages on hail-damage days (per crop) and on acres damage per day (per crop). Because of space limitations, material presented represents only a selected few of the many facts and illustrations that are available or needed to totally describe the economics of hail loss in the United States.

Hail damages most crops grown in this country, and the crops most easily damaged are fruits which lose their value (quality) from even slight bruising produced by small hail. Tobacco is ranked second, followed in order of susceptibility to damage by certain vegetables, soybeans, barley, rye, wheat, corn, cotton, sugar beets, potatoes and sorghum (Jones, 1969). However, the major crop losses from hail in the United States and their loss (as a percentage of the 1963–67 national estimated total) are wheat (51%), cotton (11%), corn (10%), soybeans (9%), and tobacco (7%) (Jones, 1969). On the average about 30% of the national tobacco crop, 25% of the wheat crop, 20% of the corn crop, and 20% of the national soybean crop are insured (Jones, 1969). Property loss primarily involves structures, livestock, trees and vehicles. For example, property damages produced by a very severe hailstorm in St. Louis included losses to roofs (75% of total property loss), awnings (13%), exterior paint (7%), glass (5%), and to siding (3%), as measured in a detailed storm study by Collins and Howe (1964).

2. Data and analysis

The primary data employed in this study were furnished by the Crop-Hail Insurance Actuarial Association (CHIAA) of Chicago which has been in existence for 25 years, and is a conglomerate of about 100 companies that together have insured 60–70% of the all insured crop value in the United States over the past 20 years. However, only 14% of the United States 1964 crop value was covered by hail (commercial and federal) insurance (Brown, 1967); but this insured crop value has amounted to $3.5 billion or more per year since 1967.

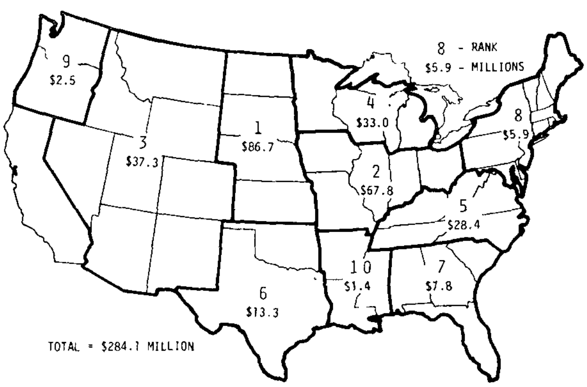

Fig. 1. Regional average annual crop-hail losses (1948–67) and their rank.

Table 1. Liability, premium, and loss totals for crop-hail insurance groups in 1969.

	Values in millions of dollars		
	Liability	Premiums	Losses
Commercial			
CHIAA	2136.4	88.1	50.2
Other companies	1390.2	25.1	21.0
Sub-total	3526.6	113.2	71.2
FCIC	unknown	49.0	47.3
National total	3526.6+	162.2	118.5

In some instances, available data from the other commercial insurance companies (mutual and stock) and from the Federal Crop Insurance Corporation (FCIC) were employed. The insurance values for these three sources in 1969 are shown in Table 1. The CHIAA liability total is 61% of the total liability (commercial) assumed in 1969. CHIAA represented 54%, FCIC 30%, and other commercial companies collected 16% of the total premiums.

The CHIAA has kept very detailed daily storm loss-liability records by county (and by townships in some states) for all hail-loss states. These extensive data have been employed by the Illinois State Water Survey and others in a wide variety of hail research studies, and represent a unique and valuable resource. Basically, these data have been summarized by year and by area as to amount of liability ($ crop value insured), amount of premium ($ charged for insurance), amount of loss ($), loss ratio (a percent, $ loss divided by $ premium), and loss cost (losses divided by liability, then multiplied by 100). Thus, loss cost is the dollars of loss per $100 liability, and can be computed for individual crops or all combined. Although the amount of insurance has varied with time and area, the loss ratio and loss cost values are normalized figures and can be used in time-space comparisons.

The inadequacy of the weather loss data in *Storm Data*, the NOAA published summary of all individual storm losses by states, is revealed by values in Sanders (1971) study of national weather losses wherein he used *Storm Data* as a source for 1963–70 losses. His derived 7-year total national hail loss value yields an annual

TABLE 2. Ten leading hail states, as based on CHIAA insurance data, 1960–69.

Rank	Liability ($ million)	Premiums ($ million)	Number of paid losses (1000's)	Individual paid losses ($1000's)	Total loss ($ million)
	States and annual average values				
1	Ill (315.1)	N Car (9.0)	N Car (10.8)	Idaho (1.8)	N Dak (5.5)
2	N Car (190.8)	N Dak (8.4)	Ky (9.8)	N Y (1.7)	N Car (5.0)
3	Iowa (161.5)	Tex (6.3)	N Dak (9.3)	Ore (1.6)	Tex (4.6)
4	N Dak (112.6)	Nebr (6.2)	Iowa (8.2)	Fla (1.5)	Iowa (3.9)
5	Nebr (91.5)	Kans (5.8)	Kans (7.8)	Calif (1.4)	Nebr (3.7)
6	Kans (86.0)	Iowa (5.4)	Nebr (7.7)	Ariz (1.4)	Kans (3.5)
7	Tex (84.4)	Ill (5.0)	S Dak (5.4)	Pa (1.3)	Ill (2.4)
8	Minn (73.7)	Minn (4.5)	Ill (5.0)	Wash (1.2)	S Dak (2.4)
9	Wash (64.2)	Mont (4.1)	Tex (4.5)	Mont (1.1)	Minn (2.2)
10	Ky (59.9)	S Dak (3.5)	Minn (4.4)	Colo (1.0)	Ky (1.9)

average loss of $47 million. Crop-hail losses recorded by CHIAA companies in this period alone averaged $54 million annually. Since the CHIAA value is based on insurance covering only 10% the national crop value, the *Storm Data* hail values are exceptional underestimates of the true loss.

3. Spatial distribution of loss

The annual crop-hail losses throughout the United States, based on 1948–67 averages, are estimated at $284 million at 1968 price levels (Jones, 1969). In general, this estimated national loss was determined by adjusting the known crop-insurance hail losses according to the percent (16) of the total national crop value they represented in 1968. Such estimated total crop loss values (and their rank) for ten crop regions in the United States are shown in Fig. 1 (Jones). Although unequal-sized areas, these regional values provide a general impression of the spatial distribution of loss for different agricultural areas. The Great Plains area, where wheat is the major damaged crop, has an annual average loss of $86.7 million and ranks first nationally.

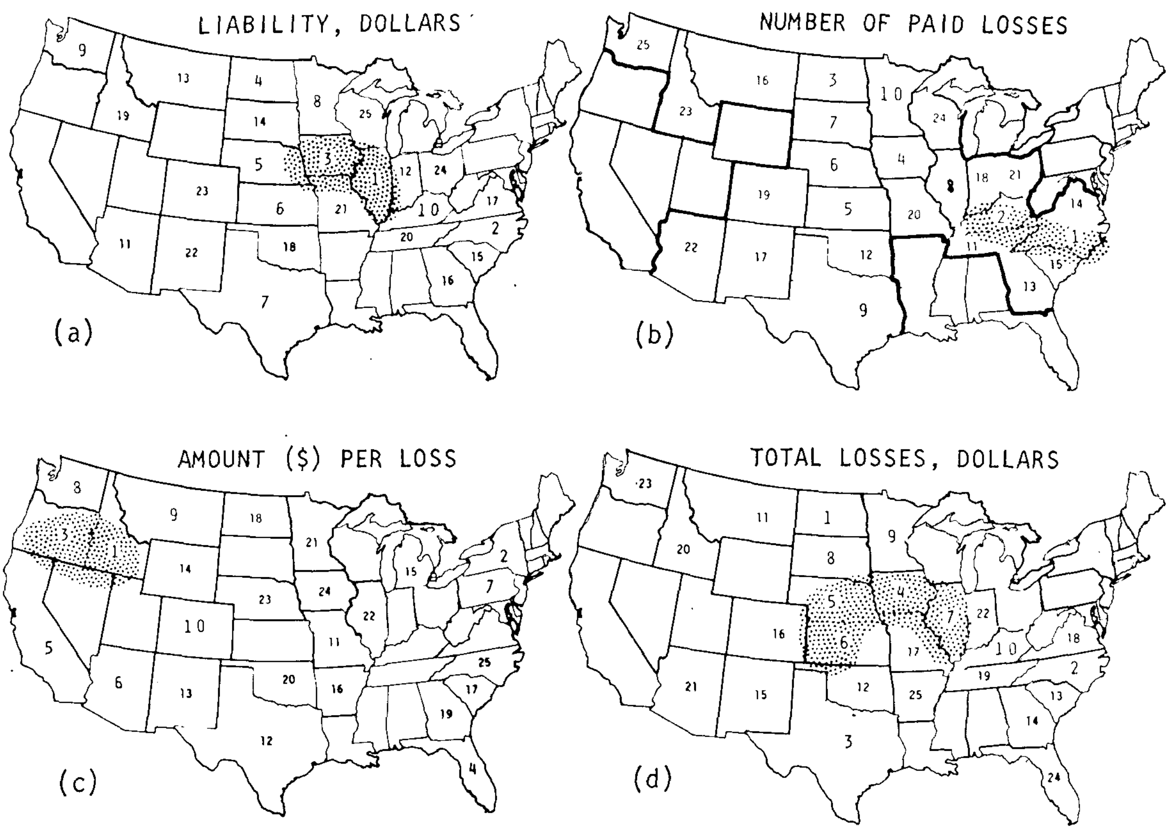

FIG. 2. Ranks of state average values of liability, paid-loss frequency, individual paid losses, and total losses, 1960–69 period.

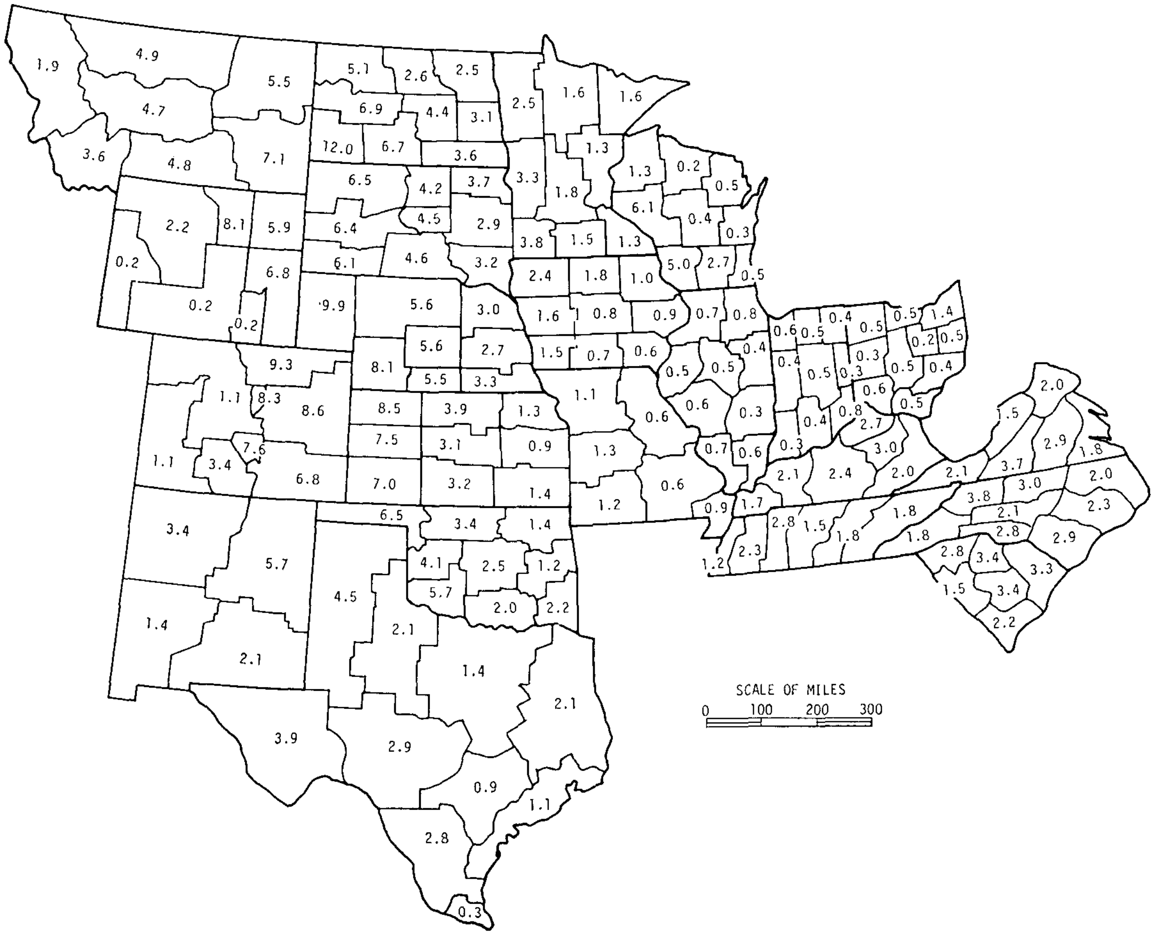

Fig. 3. Crop-district average loss costs, 1948–67. Loss cost is (loss÷liability)×100.

The Corn Belt, where corn and soybeans are the "damage" crops, ranks second, and thus 54% of the national hail loss to crops is in the central United States.

Available CHIAA insurance data (55% of the 1969 national insurance premium total and an estimated 9% of the total national crop value for 1969) for the 1960–69 period were used to develop state values of various insurance-loss parameters including the total liability ($), total premiums ($), number of paid losses (each a farm or portion thereof), average amount of the individual paid loss ($), and the total monetary loss. The national average annual values were $1,782.6 million in liability, $80.3 million in premiums, 96,949 paid losses, $556 paid per loss, and $53.9 million in losses. The ten highest ranked state values listed in order in these five categories appear in Table 2. Illinois and North Carolina lead in liability with 28% of the national total insured crops, and North Carolina leads in premiums, representing nearly 12% of the national total. Kentucky and North Carolina lead in the number of paid losses per year; Idaho and New York lead in the average amount paid per loss; and North Dakota and North Carolina lead in the total losses, representing 20% of the national total. Examination of Table 2 reveals that basically the same states appear in all the lists except for those in the individual paid loss list where specialty crops (fruits and vegetables) in relatively low hail frequency areas (such as New York, Oregon, Florida and California) are heavily insured and receive large losses and high payments when hail does occur.

The values for four insurance-loss categories were used to determine the highest 25 ranking (rank 1 = greatest value) states, and these rank values appear in Fig. 2. The same 25 states have achieved ranks in all but the amount-per-loss map, and these 25 states are defined as the prime loss states in the United States. Envelopes were constructed around those two to four adjoining states on each map where the highest ranks are found to help define the prime areas. The Illinois-Iowa-Nebraska area is shown to be the principal area in liability and total losses. However, the greatest frequency of paid losses occurs in the North Carolina-Kentucky area, largely because this is a tobacco-loss area and individual insured tobacco areas are very small and many losses can occur per hail loss day. The ranks

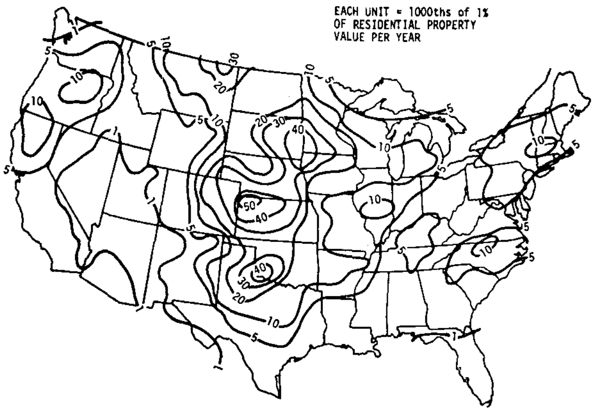

FIG. 4. Index of potential hail damage to property (after Collins and Howe, 1964).

of the amount-per-loss show a widely varying distribution nationally, and this is related largely to the locations of high value, easily damaged crops. Ironically, Kansas and South Dakota, which have high ranks in liability, premiums, loss frequencies, and in total loss do not rank in the top 25 states in amount-per-loss, with an average loss per claim of $456 and $438 respectively.

Illinois and Iowa have low loss cost values and low losses per paid claim (Fig. 2) indicating low hail severity per storm, but these two states rank high nationally in the frequency of paid losses and in total loss (Fig. 2) because of the extensive liability and insurance. More than 55% of the crop-land in both states is normally insured. The average Illinois policy costs $118 per year (for 125 acres, on the average), as compared to $521 in Colorado for 97 acres. Illinois crop-hail losses per $100 liability are 15–20 times less than those in eastern Colorado, and this difference is directly related to regional differences in hail intensity (hailstone size and frequency) as shown by Changnon and Stout (1967).

A more detailed portrayal of the national spatial variations in crop-hail loss appears in Fig. 3. Here the crop-district average loss costs (a figure normalizing loss in dollars to liability in dollar times 100 and for all crops), based on 1948–67 data from CHIAA, are plotted (Stout, 1967). The highest district loss is $12.1 in southwestern North Dakota, and in general, the highest losses (>$6) are oriented N-S along the east side of the Rockies. Values decrease rapidly away in all directions, and to the east they become less than $1/$100 in the Mississippi Valley. In the tobacco-loss states (Kentucky, Tennessee, Virginia, and the Carolinas), the loss cost values are higher than those in the Corn Belt.

Without quality property loss data, the regional evaluation of loss by property insurance interests has often followed an empirical approach. A study by Collins and Howe (1964) used 10 years (1953–62) of published values in *Storm Data* (with its known underestimates of total loss), and coupled these values, on a regional basis, with an average storm size value and with results from case studies of property hail losses to derive an index of (property) damage potential. These indices were computed for each area formed by 1° of latitude and 1° of longitude, and a pattern based on these appears in Fig. 4. The area of greatest potential property damage (based largely on the losses in the 1953–62 period), as defined by the 20-isoline, is in the Great Plains. The major axis of this area extends from north-central Texas into southern Minnesota, and thus is 100–300 mi east of the major axis of crop-hail loss (loss cost ⩾$4) which, in Fig. 3, would extend from the Texas Panhandle, Texas-New Mexico border to northwestern North Dakota.

Fig. 5 shows the pattern of loss to soybeans from a single hailstorm in central Illinois (Changnon and Barron, 1971). This pattern is included to reveal loss variability on a much smaller scale, and such a pattern frequently represents the annual loss pattern in a small midwestern area since only one damaging storm normally occurs over a few square miles. Note the great variability ranging from 10–90% loss in 0.1 mi in section 28. This storm produced losses at a total of 24 farms, 13 of which were insured.

4. Temporal distribution of loss

Examples of the temporal variations in the national and state crop losses due to hail are shown in Fig. 6. These are yearly loss ratios (losses divided by premiums) for 1952–69, and inspection of the three state curves reveals 1) the great temporal variability, 2)

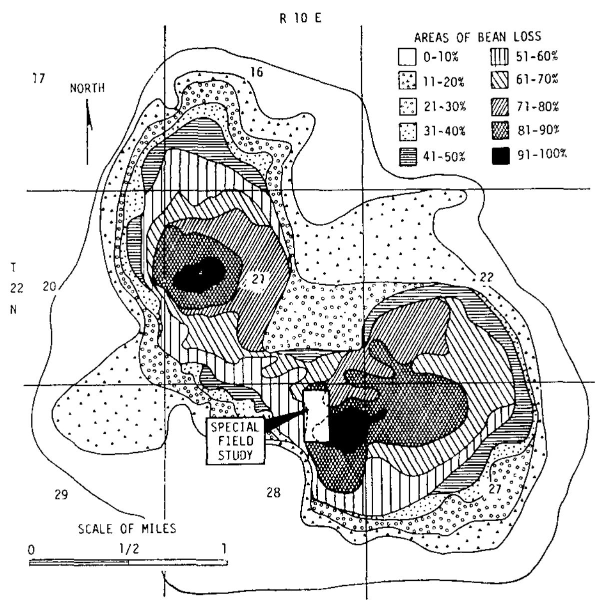

FIG. 5. Soybean loss pattern for single hailstorm in central Illinois on 11 July 1969.

distinct tendencies for time-isolated single large-loss years separated by several low-loss years, and 3) no apparent relationship in loss cycles between states. Illinois had loss ratios varying from a low of 12% in 1957 to a high of 178% in 1953.

The national loss ratio curves show fluctuations ranging from 45% in 1959 to 81% in 1956. Statistical analysis of CHIAA loss ratios for the 1934–69 period indicates no cyclic fluctuations. Since 1955, or when crop-hail (all commercial insurance) premiums exceeded $2 million, the average annual national loss ratio has been 63% and the average annual paid losses were $65.1 million (ranging from $84.8 million in 1967 to $45.3 million in 1959).

The type of temporal distributions shown by the state graphs (Fig. 6) have portent for hail insurance companies and the insured. First, the sporadic, infrequent nature of large losses indicate that hail insurance should be purchased and retained over a long period of time. Second, from a marketing standpoint, hail insurance rates must fluctuate since selling of the insurance becomes difficult after a series of low loss years, and thus the price is generally decreased with time. Then after one or two bad loss years (such as 1956 and 1957 in North Dakota), rates are usually increased over the entire state. Third, the fact that one or two very bad loss years can occur in one state (and often not in other states in the same year) also means that insurance companies need to defray their risk (insurance) by selling over areas larger than one state.

The temporal variability of loss is even greater in smaller areas. Fig. 7 shows the number of damaged acres per year in two adjacent 3800 mi² areas in central Illinois over a 20-year period. Area 4 losses ranged from 550 acres in 1949 to 40,220 acres in 1965. The sizeable differences between areas over several years reveal the problems that exist 1) for a company in choosing

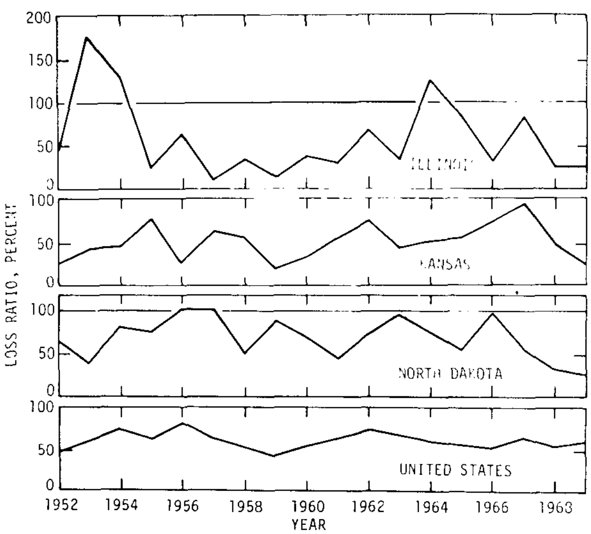

FIG. 6. Annual crop-hail loss ratios, 1952–69.

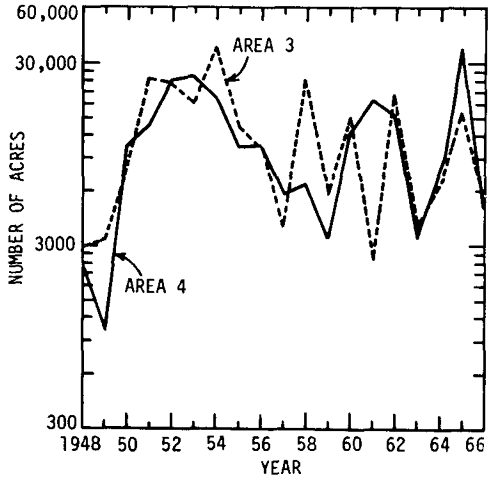

FIG. 7. Yearly areas of crop loss in two adjacent 3800-mi² areas in central Illinois.

properly the insurance density per unit area, and 2) for experimenters concerned with the use of a target-control design for hail suppression experiments (Schickedanz and Changnon, 1970).

An important aspect of hail loss is the fact that much loss in any state usually occurs on only a few days. For instance, Illinois normally has 63 loss days per year, but normally 50% of the total state loss comes on only 2 days of the 63, and 75% of the total on 6 days (Blackmer *et al.*, 1959). This very skewed distribution in major (catastrophic) hail loss days is further illustrated in Table 3 which is based on selected major storm days in three states (Brown, 1967). The Illinois "storm" of 19–20 June consisted of 32 major hailstorms in a 16-hr period, and this period of activity accounted for 76% of the total 1964 losses in Illinois. These "catastrophic" storm days are great problems for the many non-insureds who suffer total loss over an entire 200–300 acre farm, as well as for the insurance companies. Thus, these storm days represent a major problem for insurance planning and for future operational considerations in hail suppression efforts.

TABLE 3. Examples of hailstorm occurrences of a catastrophic nature.

	Losses for storm occurrence*	Total state losses for year*	Losses for storm occurrence as percent of total for year
Illinois			
1964: 19–20 Jun	$4100	$5400	76
Kansas			
1966: 7 Jun	2300	3300	70
1962: 24 May	1300	4700	28
North Dakota			
1966: 24 Jun	2200	8600	26
5 Aug	1500	8600	17
8 Jul	1300	8600	15
23 Jul	1300	8600	15

*In thousands of dollars, from CHIAA.

TABLE 4. Average annual number of hail-loss days (1957–68).

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total
				Wheat					
Texas	8	24	26	5	0	0			63
New Mexico	0	5	9	3	0	0			17
Oklahoma	11	26	22	3	0	0			62
Kansas	9	30	22	15	0	0			76
Missouri	4	17	16	5	0	0			42
Nebraska	2	19	28	24	4	0			77
Colorado	0	13	21	20	4	0			58
Wyoming	0	2	11	14	4	0			31
North Dakota	0	3	23	29	26	6			87
South Dakota	0	6	23	28	15	1			73
Minnesota	0	1	13	20	13	2			49
Washington	0	2	4	4	2	0			12
Oregon	0	1	3	4	3	1			12
Montana	0	2	20	25	20	4			71
Idaho	0	1	7	9	10	4			31
				Corn					
Indiana		1+	6	9	6	2	0		24
Nebraska		4	19	27	24	13	0		89
Iowa		5	21	26	23	11	3		90
Kansas		0	4	7	5	2	0		18
Missouri		3	8	10	6	2	0		29
Wisconsin		0	2	6	6	2	0		16
Ohio		0	2	2	2	1	0		7
Illinois		3	12	17	13	5	0		50
Minnesota		2	11	21	21	6	1		62
South Dakota		1	12	21	24	6	0		64
				Soybeans					
Ohio		0	2	2	2	1	0		7
Indiana		1	8	10	6	3	0		28
Iowa		6	23	23	21	13	4		90
Missouri		6	6	8	5	4	2		31
Minnesota		2	16	22	19	9	2		70
Illinois		5	18	17	12	4	4		60
				Cotton					
Texas	3	21	24	21	15	13	10	2	111
New Mexico	1	11	12	13	11	6	7	1	63
Oklahoma	0	3	4	3	1	2	1	0	14
Arizona	0	0	3	10	14	5	4	2	38
Missouri	0	6	7	5	3	0	0	0	21
				Tobacco					
Kentucky	0	7	25	24	28	17	3	4	108
Tennessee	0	4	16	25	24	11	3	2	85
North Carolina	4	21	23	26	25	10	3	1	113
South Carolina	5	17	17	14	8	0	0	0	61
Virginia	0	5	13	17	16	5	1	0	57

5. Daily loss statistics

The skewed distributions of daily loss values per year in each state have already been described. Previously unavailable statistics on the frequency of crop-loss days and the daily areal extent of loss (by state and by crop) have been gleaned from CHIAA data for the 1957–68 period.

The average monthly frequencies of loss days for the states where corn, soybeans, cotton, tobacco and wheat losses are greatest appear in Table 4. Iowa leads in the total average frequency of loss days for corn and for soybeans; Texas leads for cotton (111 days of loss per year); North Carolina for tobacco (113 loss days); and North Dakota for wheat (87 loss days annually). The distributions of monthly loss values for any crop are a result of the state hailstorm frequencies plus the availability of crops. For instance, no wheat loss days occur after July in Texas and Oklahoma since the crop has been harvested before August, but in North Dakota, loss days occur as late as September.

Table 5 provides average monthly numbers of acres damaged for the five major damage crops in the United States and in the various prime hail states. For instance, the average wheat loss area in Kansas on a June hail day (based on CHIAA data) is 12,553 acres (about 2 mi^2). As shown in Table 5, large temporal variations appear between monthly values of a given state, and there are large differences between the values of different states. For example, Illinois and Iowa have similar amounts of insured areas (55% of the states' croplands), but the average corn loss areas on a damage day in Iowa (in all months) exceed those in Illinois.

TABLE 5. Average number of acres with hail damage on loss days, 1957–68.

	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov
				Wheat				
Washington		666	2246	1080	580			
Oregon		1190	4520	688	480	80		
Oklahoma	3347	6194	3600	180				
Texas	1370	4040	5330	215				
New Mexico		1733	1936	320				
Kansas	2823	10050	12553	3151				
Missouri	400	418	425	90				
Nebraska	662	3450	5000	3315		101		
Colorado		2288	3886	2900	175	101		
Wyoming		234	686	1023	256			
South Dakota		475	2542	5043	1704	264		
North Dakota		295	4600	15700	7500	1291		
Montana		902	4412	7350	3242	423		
Minnesota		70	450	1074	600	161		
Idaho		330	552	517		400		
				Corn				
Indiana		110	540	310	577	252		
Nebraska		216	2434	5450	4000	1170		
Iowa		270	3118	4486	3938	1002		
Kansas			209	285	140	218		
Missouri		137	518	300	202	126		
Ohio			180	128	230	81		
Wisconsin			200	165	142	100		
Illinois		126	1067	1352	835	700		
Minnesota		83	760	3330	2732	659		
South Dakota		232	908	2583	2402	1141		
				Soybeans				
Indiana		137	650	268	305	430		
Iowa		493	1996	2172	1560	838	609	
Missouri		116	340	275	190	281	115	
Ohio			220	80	150	36		
Illinois		503	2270	1061	622	1230	960	
Minnesota		85	1142	1589	1445	609	160	
				Cotton				
New Mexico	205	1909	1924	1107	535	901	1056	660
Texas	302	4053	5625	2519	1128	2120	2787	2003
Oklahoma		259	250	165	114	120	169	
Arizona			480	582	494	700	771	330
Missouri		614	449	285	326			
				Tobacco				
Kentucky		11	112	449	224	102	5	3
Tennessee		4	33	83	72	27	4	2
North Carolina	42	516	522	352	187	73	14	1
South Carolina	140	181	138	126	67			
Virginia		30	131	109	101	75	7	

6. Comparison of hail loss with other weather losses

A considerable effort was extended to gather detailed loss values for all forms of severe local storms in Illinois during the 1950–57 period. Weather Bureau records, insurance files, newspapers, and county loss records were examined to derive a detailed description of loss for this 8-year period.

The single greatest loss year was 1957 with $33.8 million in losses (Table 6), or 26% of the 8-yr total of $131 million. The losses in 1957 are itemized in Table 6 to reveal the breakdown in a single major loss year. Interestingly, the maximum dollar loss amount was produced by the several severe 1–2 day rainstorms (and resulting flooding), and these rainstorms resulted in 12 deaths, exceeded only by the 15 tornado-produced deaths in 1957. Examination of the yearly loss data for the 1950–57 period in Illinois reveals that when the state has a major weather loss year, it is largely due to exceptional tornado losses and/or many severe short-duration rainstorms.

Annual average crop and property losses, based on 1950–57 data, due to severe local storms (as opposed to droughts, frost, and/or excessive heat) are presented in Table 7. The annual average number of deaths for 1950–57 period was 5 from lightning, 4 from tornadoes, 2 from winter storms, 2 from heavy rains, and less than 1 per year because of winds, resulting in an average annual weather death total of 13. The annual average number of persons injured by severe local storms is 108. As shown in Table 7, the average annual state total severe weather loss is $16.4 million with $4.1 million, or 25%, produced by hail. Hail losses rank first in Illinois, followed closely by losses from heavy rain, and those from winds. Wind losses are largely realized in property damages, whereas the crop losses are largely due to hail.

The lack of good crop-loss data for forms of severe weather other than hail makes comparisons of their losses difficult on a national scale. However, a survey of 447 farmers in the five-state Corn Belt conducted in 1963 (Brown, 1967) provided the results for corn and soybean weather losses shown in Table 8. Drought ranks first in all three subdivisions of the Corn Belt and for both crops, and excessive moisture and wind damages also produced greater average yield losses per year than did hail. Hail ranked relatively higher as a soybean loss factor than as a corn loss factor, and hail became less important as a loss producing factor in both crops in the more eastern areas of the Corn Belt. Table 8 results suggest that modification of rainfall (increases or decreases) would be more meaningful economically than would hail suppression in this five-state area.

Hail loss, when compared with the total weather-related corn losses shown in Table 8, represents loss values (from west to east) of 16%, 9% and 5% of the total regional weather losses. Hail losses, as a percent of the total soybean weather losses (west to east), are 25%, 15% and 8%.

Jones (1969) indicates that for the Federal Crop Insurance Corporation (FCIC) policies (which cover all "weather periods"), hail on the national scale has accounted for 14% of the paid wheat losses, 6% of the cotton loss, 7% of the corn loss, 15% of soybean loss, 17% of the tobacco loss, and around 25% of that for various fruit and vegetable crops. Although the total national crop loss from hail is high, hail is far from being the primary weather-related crop-loss factor in most parts of the United States.

TABLE 6. Dollar losses, deaths and injuries from severe weather in Illinois in 1957.

	Dollars	Deaths	Injuries
Hail	$ 2,120,000	0	1
Winds	380,500	1	0
Tornadoes	7,805,000	15	105
Lightning	151,000	4	7
Heavy rains	23,075,300	12	10
Winter storms	258,000	1	18
Totals	$33,789,800	33	145

TABLE 7. Average annual property and crop losses in Illinois due to severe local storms, 1950–57.*

	Average loss (thousands of dollars)		
	Property	Crops	Total
Hail	460.9	3,680.0	4,140.9[1]
Winds	3,352.0	386.8	3,738.8[3]
Tornadoes	2,453.6	10.2	2,463.8[4]
Lightning	105.0	3.0	108.0[6]
Heavy rains	2,635.0	1,503.8	4,138.8[2]
Winter storms	1,780.3	0.0	1,780.3[5]
	10,786.8	5,583.8	16,370.6

* Superscript indicates rank.

7. Property-hail loss estimates

The 18 summer hailstorm days in the 1915–50 period in Illinois producing the greatest losses in this 36-year period were determined for a study of various meteorological and economic aspects of these damaging storms (Changnon, 1960). Monetary losses produced by the 18 storm days ranged from a high of $3.2 million to a low $0.1 million, as normalized to 1910–14 price indices. Three storm days each produced more than 1 million dollars (adjusted) in damage, and 13 days had losses in excess of a quarter of a million dollars. The 18 storm days produced an adjusted total of $11.7 million in losses for an average of $0.7 million per storm day. The individual storm losses to crops also were expressed as a percent of the annual crop value, and the three highest storm-day values ranged from 0.3 to 0.4% of the state total. These appear small, but a 0.4% loss in 1970 would amount to $5.6 million.

TABLE 8. Annual estimated crop yield losses due to various weather conditions in the five-state cornbelt area.

	Average annual (bu acre^{-1})					
	Western Corn Belt (Nebraska, Western Iowa)		Central Corn Belt (Eastern Iowa, Illinois)		Eastern Corn Belt (Indiana, Ohio)	
	Corn	Beans	Corn	Beans	Corn	Beans
Hail	3.50^{4}	2.36^{2}	1.88^{5}	1.38^{3}	1.25	0.88^{5}
Wind	3.67^{2}	1.01^{4}	3.88^{3}	0.94^{5}	3.79^{3}	1.19^{4}
Drought	7.30^{1}	2.67^{1}	5.40^{1}	2.72^{1}	8.74^{1}	3.67^{1}
Excessive moisture	2.71^{5}	1.60^{3}	4.88^{2}	2.59^{2}	6.94^{2}	2.83^{2}
Excessive heat	3.53^{3}	0.85^{5}	2.27^{4}	1.12^{4}	2.99^{4}	1.70^{3}
Excessive coolness	0.30	0.33	1.47	0.37	1.51^{5}	0.73
Freeze or frost	1.10	0.57	0.94	0.38	1.43	0.42
Totals	22.11	9.39	20.72	9.50	26.65	11.42

Superscript indicates ranks.

Losses from crop damages accounted for a large proportion of the total loss in most storms. On only one storm day did the property damages exceed crop damages, and on four storm days no property losses were recorded. Property damages accounted for 9% (~10:1 ratio of crop to property loss) of the total 18-storm losses.

The detailed study of property and crop losses in Illinois for 1950–57 revealed (Table 7) that crop-hail losses were $3,680 thousand as compared to crop-property losses of $460 thousand. Thus, the crop loss-property loss ratio for hail was 8:1.

8. National hail losses—A summary

Two different studies (Brown, 1967; Jones, 1969) have indicated that the total national insurance liability represented crop values amounting to about 15% of the total national crop value. Known insurance losses and this percentage were used by Jones (1969) to estimate the national crop losses due to hail. The annual average crop-hail loss estimated by this procedure is $284 million (at 1968 price levels). This represents 1.3% of the national crop production. This agrees with earlier findings in that Lemons (1942) showed that crop-hail losses during 1909–25 period were 1% of the yearly national agricultural income.

Values in Table 8 suggest that national losses due to drought are about twice as great as hail losses. In fact, various data presented in this paper indicate that hail losses, on the average, are only about 10% of all the weather-related crop losses in the United States. If this is true, then 10–15% of the annual national crop value, on the average, is lost to weather factors. This roughly-estimated national crop weather loss thus amounts to about $3.0 billion annually.

Data on property loss from hail are unavailable on a national scale. However, two detailed loss studies in Illinois, one based on all losses in the 1950–57 period and the other on the 18 most damaging summer hailstorm days in Illinois, indicate crop-property loss ratios of 8:1 and 10:1, respectively. If one chooses the median ratio of 9:1, and uses the $284 million average crop-hail loss, the estimated annual average property loss from hail is about $31.0 million. This might be considered a conservative hail estimate since Illinois hailstorms produce fewer large property damaging hailstones than storms in the Rocky Mountain and Great Plains area (Changnon, 1971). However, there is less property per unit area in the Great Plains, so it might be a reasonable estimate. This lack of data on property-hail loss is one of the key problems in an economic analysis of hail loss.

Acceptance of this rough estimate of property-hail damage with the estimated crop-hail property damage value indicates that the national annual average loss due to hail is about $315 million. Approximately 15% of the national crop-hail loss is protected by crop insurance which costs Americans about $160 million annually.

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