THE RATING OF CROP-HAIL INSURANCE

BY

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Introduction

Crop-hail insurance is the name of that type of coverage which insures a farmer against loss resulting from hail damage to growing crops. Hail, though the basic hazard, is not the only peril insured against, as the crop-hail policy also provides protection, depending upon the crop and state, against fire, lightning, livestock, wind (when accompanied by hail), aircraft, and vehicles.

In addition, experimental coverage called crop-failure insurance is offered in specific counties in a few states. Added as an endorsement to the crop-hail policy, it provides disaster protection against many additional perils such as drought, excess moisture, insects, etc. Very little of this coverage has been written, however, since its introduction in 1956.

Also, to say that crop-hail insurance applies to growing crops only, is not strictly correct. For selected crops and states, crop-hail insurance is extended to cover crops until they have been unloaded at the first place of storage. One special policy covers tobacco while in the curing and pack barns and until delivered to the sales warehouse.

Up until 1948 crop-hail insurance rating was accomplished in a relatively informal manner by committees of company men. Only a few states required filing of crop-hail insurance rates and forms, and stringent regulation for this field had not yet come into being. Public Law 15 gave impetus to the already existing desire to develop a more scientific rate structure. Consequently, on December 5, 1947, the stock fire insurance companies organized the Crop-Hail Insurance Actuarial Association and made its scope national. It was the decision of the companies to have a professional meteorologist in charge of the Association, and the author was hired as its Manager.

A tremendous task faced the Association at its start. Rate and form filings had to be made in all states to meet the January 1, 1948 deadline date set by Congress. Statistical information had to be obtained from the 5 regional organizations then in operation, forms printed, and justifications prepared. This was all accomplished and member companies of the Association met all requirements of the new filing laws when they wrote their 1948 business.

After the initial problems had been solved, there was still much work to be done. The consolidation of the detail statistical data and the conversion of this from manual to punched card records took years. Informal, subjective rate-making methods had to be reworked, changed and put in writing.

This paper covers the present status of crop-hail insurance rating, as accomplished directly for the members and subscribers of the Crop-Hail Insurance Actuarial Association, the bulk of whom are stock fire insurance companies. In 1957, the affiliated companies of the Association wrote 63% of all crop-hail insurance written in the United States, and 73% of the premium volume.

To my knowledge this is the first comprehensive survey ever written regarding the rating of crop-hail insurance. The principles and methods described include those basic developments of the pioneer hail insurance men without which the rating systems of today could not exist, and also the many developments since the formation of the Crop-Hail Insurance Actuarial Association. The future of crop-hail insurance rating is explored, and it becomes apparent that the application of scientific methodology to it is in its infancy, the potentials for future improvement being indeed large.

I. BACKGROUND INFORMATION

A. *History of Crop-Hail Insurance**

Crop-hail insurance is comparatively new in the United States as compared to Europe. As early as 1797, a hail insurance organization known as

* Much of the historical information concerning crop-hail insurance is taken from the writings of James B. Cullison, Jr., first president of the Crop-Hail Insurance Actuarial Association, and pioneer in the development of all phases of the field.

the Mecklenburg Hail Insurance Association was formed. A similar attempt was made in France by a M. Barrau in 1801, although in 1809 a Council of State suppressed the undertaking evidently believing this to be almost an interference with divine Providence. However, the need for protection against hail damage to growing crops was so great that hundreds of associations were formed in Europe and many stock companies started offering coverage during the 19th century.

The International Congress of Hail Insurers reports that almost $55 million in premiums were written during 1957 in 13 European countries and North Africa. The leading countries by premium income were: Germany, $12 million; Italy, $10½ million; France, $10¼ million; Yugoslavia, $9¾ million; North Africa, $3½ million; and Switzerland, $2 million. Other countries writing crop-hail insurance and reporting to the International Congress were Austria, Belgium, Denmark, Spain, Greece, Luxemburg, Netherlands, and Sweden. The $55 million of European writings compares with $69 million written in the United States during 1957.

The first mutual hail insurance companies in the United States were organized in 1879, and many more started in business up to 1900, although the rate of failure was high due to lack of reserves and adequate rate structures.

The first stock fire insurance company entered the crop-hail insurance field in 1883 offering insurance in a few of the prairie states. By 1906 another entered the field and by 1912 there were probably 12 to 15 stock companies, and 35 to 40 mutuals writing this line.

The stock fire insurance companies formed the Western Hail and Adjustment Association in November 1915, and began the collection of statistical experience. At the start only premiums and losses by county were collected, but in 1917 it was decided to add the reporting of liability, and member companies went back in their records to obtain this for 1915 and 1916. Beginning in 1924 statistics were collected by governmental township (6 miles by 6 miles) for the important prairie states.

Other regional hail associations were formed in the early twenties for the Southeast, Pacific Coast states, and Texas, and at a somewhat later time an association for the Eastern states was organized. These associations made rates, devised policy forms, and developed scientific methods of loss adjustment.

The United States premium income for stock companies grew from about $3 million in 1915 to $39 million in 1947. Since an additional $19 million was written by mutual companies in 1947, the grand total of crop-hail insurance premiums for all insurers in 1947 was over $58 million.

B. *Crop-Hail Insurance Actuarial Association*

In December 1947, the Crop-Hail Insurance Actuarial Association was organized by 62 stock fire insurance companies. Originally, its purpose was to operate as a statistical and advisory organization to the state fire insurance rating bureaus giving advice as to crop-hail insurance rates and forms, but in 1953 its Constitution was amended to permit it to act as a rating organization on a national scale. In 1959 the scope of the Association was further enlarged to permit the rating of rain insurance on public events, business ventures, and private proceedings.

Operating as a non-profit research, statistical and rate-making organization it is now supported by 133 members and subscribers, most of these being stock fire insurance companies. The Association's work consists of not only the preparation and promulgation of rates and policy forms, but also the justification and filing of these with the insurance departments of each of the states. It also acts as the official statistical agent for crop-hail insurance for the states having laws providing for the appointment of same.

The Association receives money for its operating expenses by assessing its supporting companies annually, and each company pays in proportion to the amount of premiums which it wrote during the past growing season. Representatives of member companies meet each December to elect the three non-salaried officers of the Association.

The policy direction and over-all responsibility for Association affairs rests in the hands of the Executive Committee which consists of the three elected officers and eight other appointed members. The principal committee assisting the Executive Committee is the Actuarial and Forms Committee which reviews the technical phases of the Association's work, and is mainly concerned with the preparation of recommended policy forms and endorsements, and the review of rates to be charged. All the work of the Actuarial and Forms Committee is presented to the Executive Committee for final action.

Besides the Actuarial and Forms Committee, the Executive Committee has appointed a Research Committee, which studies all phases of research applying to crop-hail insurance. In addition it is responsible for developing a new experimental coverage which is added to the hail policy by endorsement, and covers growing crops against the hazards of drought, excessive heat, flood, excessive moisture, insect infestation, plant disease, wildlife, wind, tornadoes, sleet, hurricane, frost freeze and snow. A Priority Committee determines the order of states to be rated, and a Rain Insurance Committee deals with the new coverage added in 1960.

In addition to these committees, there are 18 Regional Committees assisting the Association in maintaining local contact all over the United States. These are scheduled to meet periodically to make recommendations concerning their particular areas, and have proved to be indispensable in keeping the Association in close touch with developments of agriculture and insurance in each region.

Now, though the Executive Committee sets the general policy of the Association, the Manager of the Association and his staff are responsible for putting this policy into action. There are 56 salaried employees working for the Association.

When the Association was organized in December 1947, it assumed statistical, rating and form functions formerly exercised by the various regional hail insurance organizations.* The first major task of the Association was the

* The Hail Insurance Adjustment and Research Association and the Southeastern Hail Conference have continued to operate in the fields of loss adjustment procedures and simulated hail damage research carried on by various agricultural colleges.

consolidation of the statistical information turned over to it by these regional organizations, and the transferring of this data from manual records on to punch cards.

This vast amount of accumlulated data has been kept up-to-date, and added to since 1948. Each year affiliated companies have reported their crop-hail insurance liability, premiums, and losses and this has been tabulated, and separate statistical summaries published annually for each state.

The nationwide crop-hail premium income of the Association's companies has increased from \$39 million in 1947 to \$77½ million in 1958, and \$73 million in 1959.*

C. *The Crop-Hail Insurance Policy*

Crop-hail insurance is fundamentally written as a physical per cent of damage contract.

The basic contract, known as the "percentage policy", provides that the same proportion of insurance will be paid as the proportion of crop destroyed. If 30 per cent of the farmer's crop is destroyed on any insured acre, he will receive in payment 30 per cent of the amount of insurance that he has taken out on that acre. If he has \$10.00 insurance applying to that acre, he will collect \$3.00. If he has \$50.00 insurance, he will be paid \$15.00.

If the amount of insurance equals the value of the crop, the farmer will be completely protected. If the amount of insurance equals half of the crop value, the insured will receive payment for one-half of his actual loss. In other words, crop-hail insurance has a 100% coinsurance feature similar to marine insurance.

The usual life of a crop-hail insurance policy is counted in months, being the length of the crop growing season. Generally speaking, the policy attaches when the crops insured are up to a normal stand, and the coverage continues until the crop is harvested. There is also a date in the policy after which the insurance automatically expires, but this is included primarily to protect the company against a farmer abandoning his crop.

Most policies are taken out annually at the start of the growing season. In a few states, however, three-year and five-year policies are issued, but the premium is paid annually and an endorsement is furnished giving the number of acres of each insured crop grown.

Local agents do not issue the policies, but send in applications to the company. Insurance becomes effective 24 hours after the farmer makes application, although the company has the option of rejection.

The application form requires the description of the land on which the crop is grown (county, township, and range), the kind of crop, the per cent interest that farmer has in the crop, the number of acres, and the insurance per acre desired.

Agents are supplied with specimen policy forms so that the farmer may be fully aware of the conditions of the contract for which he is applying.

* The five leading states ranked by 1959 premium income: North Carolina, \$8.2 million; Texas, \$7.7 million; Kansas, \$7.4 million; Nebraska, \$6.8 million; and North Dakota, \$5.4 million.

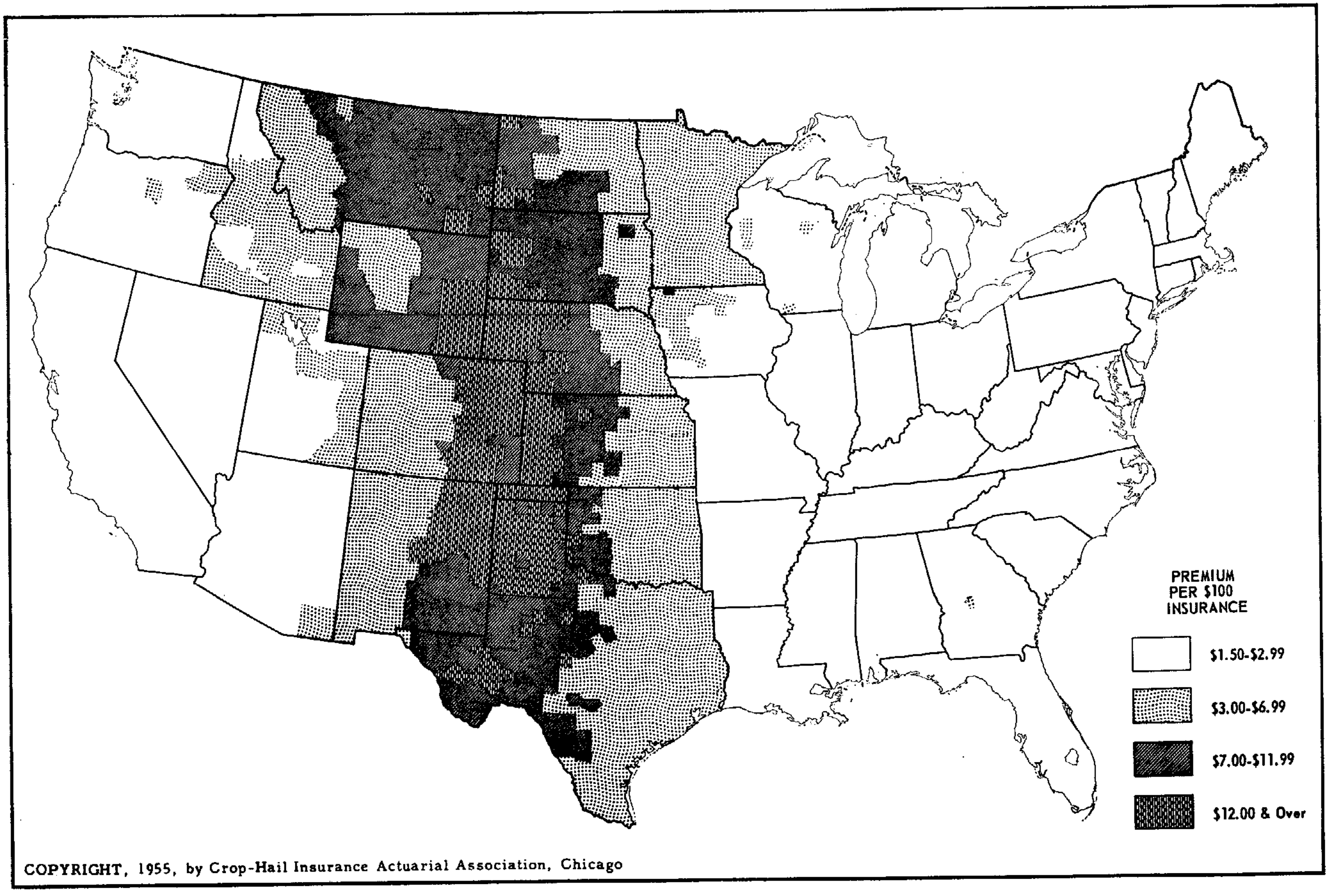

Chart 1. Average 1955 wheat rates by county for the non-deductible policy form.

The average rate charged for crop-hail insurance in the United States in 1958 was $5.14 for every $100 of insurance. The rates, however, vary considerably by geographical location, crop, and policy form. In many states different rates may be charged for each six-mile square government township.

The highest rates are charged in the western parts of Kansas and Nebraska and the eastern portions of Colorado and Wyoming. Chart 1. shows the average county wheat rates in effect in 1955.

All of the rates promulgated by the Crop-Hail Insurance Actuarial Association are based on accumulated insurance experience, as it had soon become evident that U. S. Weather Bureau data of number of days with hail was of little use in establishing usable crop-hail rates.

The method of developing rates is based on loss costs, or "pure premiums" rather than loss ratios. Liability and loss data are available back to 1924, and in many instances back to 1915. The loss cost is obtained by dividing losses by the liability or amount of insurance, and is expressed in dollars and cents per $100 of insurance. Another way of looking at the loss cost is that it is the average loss in dollars per $100 insurance.

II. GATHERING OF EXPERIENCE FIGURES

A. *Method of Reporting*

In earlier years all statistical reporting was accomplished by companies completing a summarized report of their experience by the classifications required. At a central location in each of the regions, the reports of all companies were consolidated.

In 1948, when the Crop-Hail Insurance Actuarial Association undertook the collection of statistics nationwide, this same procedure was followed, although it was provided that companies desiring the Association to summarize its liability, premiums and losses from the original documents could do so at extra cost and on a purely optional basis.

The advantages* of using up-to-the-minute experience in rate calculations became so apparent as time went on that in 1957 the Association inaugurated its current statistical reporting program. This provides for each company sending in copies of applications during the writing season, and copies of proofs of loss as adjustments are completed.

During the summer the Association places data on punched cards for those states which have been designated to be re-rated by the Priority Committee. A closing date is set for each of these states and companies are notified by bulletin. Documents received after the closing date are held until the following year, and are then included as supplemental material separately designated.

Also as part of the program, each of the companies sends in a closing report which gives the total amount of premiums and losses contained in the documents sent to the Association up to the closing date. These are used as control figures to check the data which has been placed on punched cards.

* See Part V, "Other Factors Affecting Crop-Hail Insurance Rating."

Balancing is not required to the penny, but the company totals compared to the Association totals must be within a specified range. The table setting forth the balancing requirements is so designed that the higher the dollar amounts involved, the less the permissible percentage deviation. In no case is a deviation of over 5% allowed to go unexplained, although if it is not possible to clear up a discrepancy immediately it becomes necessary to add supplemental information in the next year's summary.

Closing dates for states not being re-rated are set at a later time and the data is punched during the fall and winter months.

Companies have the option of reporting liability and premium data by punched cards in lieu of sending copies of their application, and in this case they must observe the same rules for closing dates and closing reports. Loss information is not permitted to be reported by punched cards because of the large possibility of error in coding due to the complex nature of proofs of loss.

B. *Machine Processing of Data*

The ability to include the most current experience in the cumulative record for rating purposes is possible only because of modern electronic data processing equipment. The number of crop-hail insurance punched cards to be processed each year varies between 1¼ million and 1½ million, which poses a most difficult problem for standard tabulating equipment.

The Association uses a magnetic tape I.B.M. 650 data processing system which provides extremely rapid and accurate handling of data. A further advantage of magnetic tape is the reduction in storage requirements. The ratio of space required to store magnetic tape as compared to punched cards is about the same as the ratio of space required for microfilm compared to original documents.

Punched cards are used only to enter the magnetic tape system, and are then destroyed. All historical information required to be saved is on magnetic tape.

The 650 system is well adapted to the type of statistical information needed in crop-hail insurance work. By doing many things at once the time expended is greatly reduced. Erroneous rates, faulty computations, and errors in coding are punched out in the initial phases of the work. Later on, standardized individual company reports (upon request) are prepared, and statistical summaries combining all companies experience produced. Rate analysis procedures are also included as part of the operation when re-rating has been specified.

A relatively small clerical staff is used in checking documents for coding prior to punching, and for processing errors which are indicated by the 650 machine. One of the functions of the clerical staff is to see that the totals produced by the machine are in balance with the control totals furnished by the companies.

C. *Publication of Data*

Statistical summaries are produced on a 407 tabulating machine (on line in the 650 system). These summaries are used by member and subscribing

CROP — HAIL INSURANCE

GENERAL;
HAIL AND FIRE
HAIL ONLY

TOWNSHIP STATISTICS

STATE	POLICY FORM	CROP	PERIOD	CAUSE OF LOSS
KANSAS	HAIL ONLY	ALL CROPS	1924-1958	HAIL

COUNTY		TOWNSHIP		RANGE		LIABILITY	LOSSES		LOSS COST	
CODE	NAME	NUMBER	DIR.	NUMBER	DIR.	NEAREST DOLLAR	DOLLARS	CENTS	DOLLARS	CENTS
153	RAWLINS	5	S	34	W	693148	120265	74	17	35
153	RAWLINS	5	S	35	W	596911	55475	86	9	29
153	RAWLINS	5	S	36	W	312095	14561	13	4	67
	TOTAL					12973140	1079215	89	8	32
155	RENO	22	S	4	W	1314820	28834	74	2	19
155	RENO	22	S	5	W	239582	7749	73	3	23
155	RENO	22	S	6	W	1295209	70997	81	5	46
155	RENO	22	S	7	W	1643714	76167	94	4	63
155	RENO	22	S	8	W	2039115	97093	61	4	76
155	RENO	22	S	9	W	1698576	108400	04	6	38
155	RENO	22	S	10	W	294405	19471	87	6	61
155	RENO	23	S	4	W	887338	26341	14	2	97
155	RENO	23	S	5	W	779504	12070	06	1	55
155	RENO	23	S	6	W	1581660	50601	76	3	20
155	RENO	23	S	7	W	3229095	157899	95	4	89
155	RENO	23	S	8	W	2507098	135917	13	5	42
155	RENO	23	S	9	W	2157914	140150	02	6	49
155	RENO	23	S	10	W	994715	36492	04	3	67
155	RENO	24	S	4	W	1401050	30213	34	2	16
155	RENO	24	S	5	W	628287	9960	92	1	59
155	RENO	24	S	6	W	1344750	48296	78	3	59
155	RENO	24	S	7	W	2572276	146884	64	5	71
155	RENO	24	S	8	W	2327290	81855	09	3	52
155	RENO	24	S	9	W	775458	26672	03	3	44
155	RENO	24	S	10	W	674265	15407	64	2	29
155	RENO	25	S	4	W	2283362	53053	22	2	32
155	RENO	25	S	5	W	1300913	41806	97	3	21
155	RENO	25	S	6	W	856514	56595	92	6	61
155	RENO	25	S	7	W	1090022	43643	49	4	00
155	RENO	25	S	8	W	1749318	90180	07	5	16
155	RENO	25	S	9	W	1658072	69570	52	4	20
155	RENO	25	S	10	W	549980	10389	74	1	89
155	RENO	26	S	4	W	1842658	56878	69	3	09
155	RENO	26	S	5	W	1081820	26118	51	2	41
155	RENO	26	S	6	W	597960	16143	78	2	70
155	RENO	26	S	7	W	449451	7379	74	1	64
155	RENO	26	S	8	W	1453417	51194	88	3	52
155	RENO	26	S	9	W	1976237	65558	72	3	32
155	RENO	26	S	10	W	910356	18134	72	1	99
	TOTAL					48186201	1934127	25	4	01
157	REPUBLIC	1	S	1	W	1011789	72193	25	7	14
157	REPUBLIC	1	S	2	W	486723	26669	64	5	48
157	REPUBLIC	1	S	3	W	653226	16022	82	2	45
157	REPUBLIC	1	S	4	W	1133084	39648	68	3	50
157	REPUBLIC	1	S	5	W	1146730	51243	35	4	47
157	REPUBLIC	2	S	1	W	601348	7603	96	1	26
157	REPUBLIC	2	S	2	W	682087	25569	54	3	75
157	REPUBLIC	2	S	3	W	500903	15602	59	3	11
157	REPUBLIC	2	S	4	W	1101654	38669	21	3	51
157	REPUBLIC	2	S	5	W	1195164	45637	26	3	82
157	REPUBLIC	3	S	1	W	704798	19941	53	2	83
157	REPUBLIC	3	S	2	W	549056	14352	00	2	61
157	REPUBLIC	3	S	3	W	420358	8563	21	2	04
157	REPUBLIC	3	S	4	W	642430	20675	14	3	22
157	REPUBLIC	3	S	5	W	1629766	50330	23	3	09
157	REPUBLIC	4	S	1	W	908992	27751	11	3	05
157	REPUBLIC	4	S	2	W	920114	60535	95	6	58
157	REPUBLIC	4	S	3	W	925237	47009	98	5	08
157	REPUBLIC	4	S	4	W	628629	25272	61	4	02
157	REPUBLIC.	4	S	5	W	1036217	21992	31	2	12
	TOTAL					16678305	635284	37	3	76
159	RICE	18	S	6	W	863281	16780	49	1	94
159	RICE	18	S	7	W	1095227	13346	75	1	22
159	RICE	18	S	8	W	1144016	15254	99	1	33
159	RICE	18	S	9	W	1325097	21651	74	1	63
159	RICE	18	S	10	W	925515	30345	29	3	28
159	RICE	19	S	6	W	847429	12303	33	1	45
159	RICE	19	S	7	W	1590068	24273	86	1	53
159	RICE	19	S	8	W	2123703	56418	61	2	66
159	RICE	19	S	9	W	1667836	44452	60	2	67
159	RICE	19	S	10	W	1400406	88385	74	6	31
159	RICE	20	S	6	W	861164	5010	06		58

Chart 2. A Sample Page of the 1958 Kansas Statistical Summary.

The tabulating machine's print-out sheet is photographed and printed companies to check their underwriting plans, compare their individual experience with the average of all companies, to determine areas of potential development of future sales of crop-hail insurance, and for various other purposes.

Annually, each Insurance Department receives a published statistical summary for its state, which is not only for information, but also serves as the official report for those states providing for the formal appointment of a statistical agent. (The Crop-Hail Insurance Actuarial Association has been designated as the official statistical agent for crop-hail insurance in all states requiring this.)

The publication of the summaries is simplified by the process of taking reduced photographs of the tabulating machine print-out sheets, and plates for printing are made from these.

A sample page of a statistical summary is shown in Chart 2.

III. RATING METHOD

A. *General Remarks*

Hail damage is the direct result of thunderstorm activity. The lightning, thunder, heavy rain and gusty winds of a severe thunderstorm are frequently accompanied by a deluge of frozen ice balls. These may vary from small pea-size stones of ¼″ in diameter up to the dimensions of a grapefruit, although the average size is about ½″, and it is rare to have stones fall larger than 2″ in diameter.

Hailstorms almost always occur when the temperature at ground level is considerably above freezing, spring and summer being the season of most activity. Since hailstones are frozen water (often with successive layers of clear ice and snowy, cloudy ice), they must be formed at heights where the temperature is below freezing. In summer in the central United States, the freezing level occurs at about 13,000 to 14,000 feet above sea level, and stones are formed in thunderclouds above this level.

There are two theories of formation, one postulating that a nucleus of frozen water is subject to a series of updrafts and downdrafts which transports the stone from the freezing region of cloud to the the warmer regions below. There an additional coating of water is added, and then the stone is carried again up into the freezing region, thus explaining the concentric layers of clear and opaque ice. When the stone grows to a size which cannot be supported by the updrafts, it falls to earth.

Another theory suggests that the frozen nucleus starts to fall and successively encounters supercooled water droplets and snowflakes. There is only one descent, and the amount that the stone grows as it falls depends upon how many droplets and flakes it encounters.

Regardless of how hailstones are formed, it is known that they are products of the violent atmospheric updrafts found in thunderstorms. A storm area however, is actually a region of convective activity made up of a number of thunderstorm cells. Each cell has a life cycle during which its cumulus cloud develops into a cumulonimbus or thundercloud, precipitates rain and possibly hail, and then dissipates. In a storm area, one cell may be in the cumulus stage, while another is in the mature stage, and a third may be dissipating. There is a tendency for successive cells to reach greater heights as a well-developed thunderstorm area moves across the country.

Opinions differ as to whether every thunderstorm cell contains hail. Certainly, stones do not reach the ground in most cases, but whether they melt in descent or never existed in the first place is still not conclusively proven. Hailstones reaching the ground seem to be associated with cells having higher than average updraft velocities (in excess of 35 m.p.h.).

Hail damage occurs in a path, the width of which averages from one to two miles and may be as much as ten miles wide. The length of the paths, which is dependent on the velocity of the hail-producing cell and the duration of its life cycle, will range from a few miles to 50 miles or more.

Discontinuous paths of hail can be explained by attributing the different portions to different cells, rather than by a theory that the storm cloud precipitates hail, lifts, and then showers down more hail at a later time.

Basically, the extent of damage (except for very severe storms) is relatively local in nature. Recent meteorological research has tended to confirm the long-held opinion of hail insurance men that the frequency and severity of hailstorms may differ significantly within short geographical distances, the influence of local topographic features being held responsible for this variance. However, in addition to the local variability of hail hazard, there is also a broad-scale difference in hail occurrence due to the general weather circulation as affected by large land masses and bodies of water. The local topographic features are superimposed on the large-scale pattern.

In general, meteorological knowledge about hailstorms is relatively limited, significant advances having been made only in recent years. Thus, the physical reasoning which is so useful in arriving at rating classifications in other lines has been of restricted use in crop-hail insurance. Engineering concepts with regard to occupancy, exposure, structure, and protection are vital to fire rating, and the knowledge that the probability of death increases with age is essential to the development of rates for life insurance.

We do not know much about why it hails more in one place than another. We know that in the Great Plains states the elevation of the land above sea level is important. In these same states we have reason to believe that the slope of the land in relation to the direction of hailstorm movement is of significance, although to date not enough conclusive evidence has been produced so that we can use it in our rating methods. We suspect that the presence of large bodies of water will affect surrounding land areas, and have certain other theories, but basically, our approach in crop-hail insurance rating is an empirical statistical one—and in certain areas, entirely so.

The above considerations influence crop-hail insurance rating in the following ways:

1. The number of years' experience used for rating must be as many as possible.
2. Rating zones must be small in area—for many states even a county

division is unsuitable, and rating areas must be divided by township lines.

3. Rates must be revised frequently and must include the experience of the most recent season.

1. *Length of Record*

Hail will not fall at a given location in most years, and the average percent of crop destroyed is determined by a relatively few years of damage. In other words, the annual frequency distribution of hail damage for a limited area (county or township) is very skewed.

This condition, which is true in varying degrees of all "catastrophe" insurance, renders a limited period of record of doubtful value in estimating a "true" mean. Thus, we must use the maximum number of years of record available to us to achieve any degree of predictability.

Township data (a township is 6 miles by 6 miles) is extremely unreliable. Consider the leading township in Kansas according to amount of insurance written from 1924 through 1959: Township 29S, Range 4W, Sedgwick County. The total insurance recorded for this township is $4,985,724, or an average of over $138,000 per year. Over the 36 years of record it has a mean loss cost of $4.61. The estimated standard deviation is $13.29 and the estimated standard error $2.22. If our estimate of the standard deviation is a good one, it would require *2715* years of record to reduce the calculated standard error to a magnitude which would allow us to assert that we were 95% confident that our experienced loss cost was ± $0.50 from the true mean.

This, of course, renders a township figure useless *by itself*. There are, of course, two ways in which the predictability of the mean may be increased: a) by increasing the length of record and b) by increasing the size of the area.

Fortunately, since the crop-hail coverage is a physical percentage of damage contract, it is not influenced by the declining value of the dollar or by the changing ratios of amount of insurance to value. Therefore, the entire period of record can and must be used for crop-hail insurance rating.

2. *Size of Area*

Although the predictability of the mean increases as the size of the area increases, it is at this point that we run into conflict. Meteorological knowledge and observed experience indicate local variance in hail hazard, and to make rates based on state-wide experience is equivalent to mixing oranges, apples, boxcars, and airplanes together. This is borne out by the early attempts at state-wide rating which resulted in adverse selectivity to an unusual degree: farmers in the higher hazard areas being happy to buy insurance at inadequate rates, and farmers in the low hazard areas refusing to buy at what seemed excessive rates.

The dilemma: small rating areas are necessary to satisfy the basic principle that the rate should reflect the hazard, large rating areas are essential to assure that meaningful conclusions may be drawn from statistical data.

The best approach to the solution lies in the classification of townships according to degree of hazard as determined by meteorological factors. For instance, in Kansas we have a striking correlation of elevation with loss cost.* Each township has been classified according to elevation, and then all townships grouped into like elevation categories. Consequently, instead of 2,561 individual townships, there are 33 elevation rating areas.

The following figures indicate the stability introduced by using elevation areas instead of townships. Listed are the five leading townships according to amount of liability (1924-1959), and the five elevation areas with the most business written.

5 Leading Townships

	County	*Twp.*	*R.*	*Liab. 1924-59 ($1,000)*	*Weighted L.C.*	*Mean L.C.*	*Standard Devia-tion*	*No. Years for 95% Conf. ±$0.50*
1.	Sedgwick	29S	4W	$4,986	$5.94	$4.61	$13.29	2,715
2.	Sedgwick	26S	3W	3,692	4.25	3.24	9.51	1,391
3.	Doniphan	4S	19E	3,419	1.90	2.40	4.82	357
4.	Sedgwick	28S	2W	3,383	1.59	1.34	3.22	160
5.	Reno	23S	7W	3,367	4.69	5.02	10.28	1,625

Average No. of Years for 95% Confidence ±$0.50 = 1,250 years

5 Leading Elevation Areas

	Elevation Group	*Liab. 1924-59 ($1,000)*	*Weighted L.C.*	*Mean L.C.*	*Standard Deviation*	*No. Years for 95% Conf. ±$0.50*
1.	1300 feet	$155,385	$2.26	$2.23	$1.38	29
2.	1400 feet	145,735	2.59	2.48	1.84	52
3.	1500 feet	113,266	3.30	3.06	2.30	82
4.	1200 feet	95,943	2.29	2.04	1.39	30
5.	1100 feet	73,596	1.32	1.42	1.03	16

Average No. of Years for 95% Confidence ± $0.50 = 42 years

The striking difference between 1,250 years of required record on a township basis and 42 years on an elevation group basis speaks for itself. It should be noticed that the elevation data is arranged by descending order of liability. When placed in order by elevation group, the mean loss costs rank in order from lowest to highest showing the close relationship of average loss cost to elevation.

* Losses divided by liability.

Both the mean and weighted loss costs are shown. The mean loss cost is the average of each year's loss cost irrespective of amount of liability; the weighted loss cost is the average loss cost with each year weighted by the amount of liability written.

Grouping townships by elevation group, then, gives us a large amount of statistical data capable of producing useful predictions, while at the same time each of the townships in the group is assumed to have the same degree of inherent hazard.

As additional meteorological knowledge becomes available, other factors can be used in classifying, and the result should be a net gain in predictability. If, for instance, it becomes established that the slope of the land in relation to the direction of hailstorm movement and loss cost are significantly correlated, each township could be classified by elevation *and by slope,* thus reducing the amount of unexplained variation.

3. *Frequent Rate Revision*

Because of the high degree of reliance which must be placed at present on empirical statistical data and the great length of record needed for predictability, it is essential to revise the rate structure frequently.

Consequently, every state is re-rated at least once every three years, and some states more frequently than this. The Association through its current statistical reporting is able to include the experience of the crop year just ended in the cumulative record. This has the advantage, not only of increasing the length of record an additional year, but also several additional benefits of a practical nature to be mentioned later.

As our physical understanding of hailstorms increases, it will result in more stability of the rate structure, and will reduce the need for frequent rate revisions.

B. *Basic Classifications in Rating*

Crop-hail rates are all applied on a minimum or class basis. However, the process of determining the class rate to charge is similar to that of schedule rating.

A crop-hail rate depends on three variables: 1) geographical location, 2) crop, and 3) policy form. A base rate is assigned to each geographical location and applies without alteration to one specific crop and to one specific form. Rates for other crops and policy forms are determined by percentage surcharges or credits from the base rate.

1. *Geographical*

From both practical and theoretical considerations, rates need to be quoted by subdivisions of a state. For the 1959 growing season, 64% of the nationwide premiums were written in states for which crop-hail insurance rates were quoted by governmental township (6 miles square), and 36% of the premiums were written in states where rates were quoted by county.

The geographical classification is the most important one and a base rate is determined for each location.

2. *Crop*

Within any geographical area different crops may be damaged in different degrees by the same hailstorm. Generally, sugar beets, potatoes, and sorghums are least affected by hail damage. Cotton is somewhat less hazardous than wheat, corn, and oats, and more damageable are barley, rye, soybeans, vegetables, and tobacco. Cantaloupes, cucumbers, tree fruits and nursery crops represent a high degree of hazard and usually take a considerable surcharge above the base rate.

The base rate determined for a geographical area is applied to the major crop grown within a state. Thus the base rate applies to corn in Illinois, wheat in Kansas, tobacco in North Carolina, and cotton in Texas.

The other crops are grouped by classes and the rate for each class is determined by multiplying the base rate by a factor either less than 1.00, or greater than 1.00, depending upon the relative hazard.

Insurance has been written on 194 different crops since 1948.

3. *Policy Form*

Generally speaking, the basic policy form nationwide is known as the Annual Percentage form. As previously explained, this form pays the same percentage of the insurance as the percentage of crop destroyed.

Usually, there is a minimum percentage of 5% (occasionally 10%) below which no payment is made. This is not a deductible, as full payment is made if the loss percentage exceeds the minimum. Thus, if the percent of crop destroyed is 3%, no payment is made; if the percent loss is 6%, the percent of insurance payable is 6%.

The purpose of the minimum loss provision is to keep loss adjustment costs at a reasonable level, and to discourage unjustified loss reporting in the hope of collecting part or all of the premium paid for the policy.

There are several rate-reducing endorsements which may be added to the policy. One of these is the Excess Over 10% Loss Endorsement (other percentages are sometimes used). This form provides that the farmer absorb the first 10% of the loss and the company pay the excess. The 10% is 10% of the insurance applying and is deducted from the total percent of crop destruction. If 35% of the crop is destroyed, the company pays 25% of the amount of insurance.

Another form used widely is the Excess Over 20% Loss—Increasing Payment Endorsement. This operates the same as the straight Excess over Loss form except that it provides that the percentage which the insured absorbs reduces as the percent of crop destruction increases. This is accomplished by deducting the 20% from the crop loss and multiplying the remaining percentage by 1.25. Thus, a 100% actual loss to the crop is computed by multiplying 80% by 1.25, which results in 100% of the insurance being paid.

Comparison of payments under the various rate-reducing forms and the annual percentage form are given below:

	Per Cent of Insurance Payable Under:		
Per cent of Crop Destroyed	*Annual Percentage**	*Excess Over 10% Loss*	*Excess Over 20% Loss—Increasing Payment*
3%	0%	0%	0%
6	6	0	0
10	10	0	0
20	20	10	0
40	40	30	25
60	60	50	50
80	80	70	75
100	100	90	100

* 5% minimum loss provision.

The advantage of the increasing payment provision is that the farmer may collect 100% of the insurance in the event of total loss, while under a straight Excess over 10% Loss form he is able to collect only 90% as a maximum. This raises the question in the mind of some insureds: "Why is the premium calculated by applying the rate to the total amount of insurance, when you can collect only 90% as a maximum?"

The rate for the Excess over 10% Loss form has been promulgated taking this into account, but it is difficult for many people to understand this. The increasing payment provision removes the objection, and there is actually no difference between it and a straight excess over 20% loss coverage, the rate for an Excess over 20% Loss—Increasing Payment form being precisely 25% higher than that for a straight Excess Over 20% Loss Endorsement. At each and every damage level a loss under either form will pay out exactly the same number of dollars per premium dollar received.

There are other types of rate-reducing provisions, but these are variations of the ones explained above.

Generally, the base rate is set for the Annual Percentage form and the rates for the other forms are obtained by multiplying by policy form factors which represent the relative hazard between forms. An exception to using the Annual Percentage form as a base would be in states where a majority of the premiums are written under one of the rate-reducing provisions, in which case the base rate would apply to that form.

C. *Conversion of Losses for Determination of Base Loss Cost*

It is desirable to develop base rates from all available experience regardless of crop insured or policy form written. This may be accomplished by adjusting the losses to a common base.

Since the base rate applies to that policy form and crop for which the majority of premiums statewide is written,* the losses for all other policy forms and crops are adjusted to this level by using percentage rate differentials.

For instance in Nebraska, policies with the Excess over 10% Loss endorsement attached are considered 20% less hazardous than the Annual Percentage form. The policy form factor is 0.80 and the losses over the period of record for the Excess over 10% Loss form are divided by 0.80.

Generally,

converted losses (policy form) = policy form losses (period of record) ÷ policy form factor

In the same manner losses for crops other than the one to which the base rate applies are converted by dividing by the appropriate crop factor.**

Thus, corn grown in certain counties in Nebraska is considered 20% less hazardous than wheat, the crop to which the base rate applies. The crop factor for corn therefore, is 0.80, and the actual losses over the years for corn would be converted, or adjusted, by dividing by 0.80:

The general formula:

converted losses (crop) = crop losses (period of record) ÷ crop factor

When *both* policy form and crop losses need conversion, the work is simplified by using the formula:

converted losses (policy form and crop) = losses (period of record) ÷ policy form factor x crop factor

At present there are only a few states where crop loss conversions are made, while in the remaining states the losses are considered to be as if occurring on the crop to which the base rate applies. The reason for this is that statistics have been gathered by location and crop for most states only since 1948. Even in states in which crop losses are converted, it must be assumed that losses prior to 1948 are as if occurring to the base crop.

D. *Determination of Base Loss Cost*

Once the geographical area, policy form and crop to which the base rate will apply have been determined, a base loss cost for this rating unit is calculated using the converted losses.

In Kansas an individual base rate applies to wheat written under the Annual Percentage form for a specific governmental township. The base loss cost for each township in Kansas is calculated using three factors:

1. *Individual township loss cost:* 25% of the base loss cost is determined by the all-time loss cost for the township itself. Township statistics have been gathered in Kansas since 1924, and the individual township loss cost is

* Actuarially, the policy form or crop to which the base rates apply does not matter, since the percentage differentials for all the policy forms and crops remain in a constant relationship. However, from a practical viewpoint the use of the base rate for the policy form and crop most widely insured simplifies explanation to insurance departments and the insuring public.

** Conversion of losses is accomplished by using the same crop and policy form factors as used in calculation of the expanded rate schedule. Explanation of how these differentials are developed is explained in "Policy form and crop factors", see pages 135ff.

derived by dividing the accumulated losses (converted) by the accumulated liability.

2. *County loss cost:* 25% of the base loss cost results from the all-time experience of the county within which the township to be rated is located. Accumulated converted losses of all townships within the county are divided by the accumulated liability of the same townships to obtain the county loss cost.

3. *Elevation loss cost:* 50% of the base loss cost is derived from the all-time experience of the elevation group to which the township to be rated belongs.

As mentioned previously, excellent correlation has been attained between the elevation above mean sea-level and township loss cost. Each of the 2,306* townships in Kansas has been assigned to an elevation group, the groups being arranged in 100 foot intervals.

Table 1 shows the accumulated liability, converted losses, and elevation group loss costs for Kansas. Also shown is the smoothed elevation group loss cost obtained by fitting a straight-line (least-squares method) to the actual elevation group loss costs. Chart 3 shows the excellent fit which results, the correlation coefficient being + .98. Charts 4 and 5 show similar information for Nebraska and North Dakota.

The correlations which have been obtained are unusually high, though it must be realized that the calculations involve a correlation of *means* with the elevation, rather than individual township loss costs. This results in higher values for the correlation coefficients; on an individual township basis the correlation coefficient should be somewhat less.

* There are actually 2,561 townships in Kansas, but 255 of these are partial townships having an area of 18 square miles or less. These have been combined with adjacent townships for rate analysis purposes. The resultant rate for the "partial" township is, consequently, the same as for the "master township". In the printed rate schedule all 2,561 townships are shown with base rates applying.

Table 1. Loss Cost by Elevation Group, Kansas, 1924-1959.

X Elevation (in hundred feet)	No. of Townships	Liability (nearest $1000)	Y Loss Cost	Yc Computed Loss Cost*
7	2	250	.40	.24
8	40	10,633	1.05	.59
9	100	27,189	1.04	.94
10	187	51,478	.87	1.29
11	147	73,596	1.32	1.64
12	137	95,943	2.30	1.99
13	168	155,385	2.25	2.34
14	173	145,735	2.59	2.69
15	125	113,266	3.30	3.04
16	78	72,939	3.80	3.39
17	76	63,808	3.93	3.74
18	76	47,440	3.72	4.09
19	73	61,655	4.03	4.43
20	64	57,980	4.16	4.78
21	64	51,197	5.68	5.13
22	66	45,542	5.48	5.48
23	48	25,129	6.03	5.83
24	43	21,388	7.49	6.18
25	57	30,949	6.53	6.53
26	56	32,645	5.70	6.88
27	56	30,556	7.34	7.23
28	54	26,356	8.25	7.58
29	63	28,336	8.69	7.93
30	59	24,889	8.02	8.28
31	48	19,641	8.55	8.63
32	38	14,284	7.93	8.98
33	46	11,977	8.46	9.33
34	38	12,128	10.53	9.68
35	41	14,389	10.57	10.03
36	32	12,029	10.97	10.38
37	21	7,197	10.17	10.73
38	16	5,923	9.95	11.08
39	14	4,219	10.09	11.42
Total and Average for State -	2306**	1,396,071	$ 4.15	

*Yc= 0.. 34951X - 2.20603. Each loss cost was weighted by elevation group liability in deriving equation.

** Does not include 255 partial townships. Experience of partial townships, however, is included with that of their "master" townships and is, therefore, accumulated in the above table.

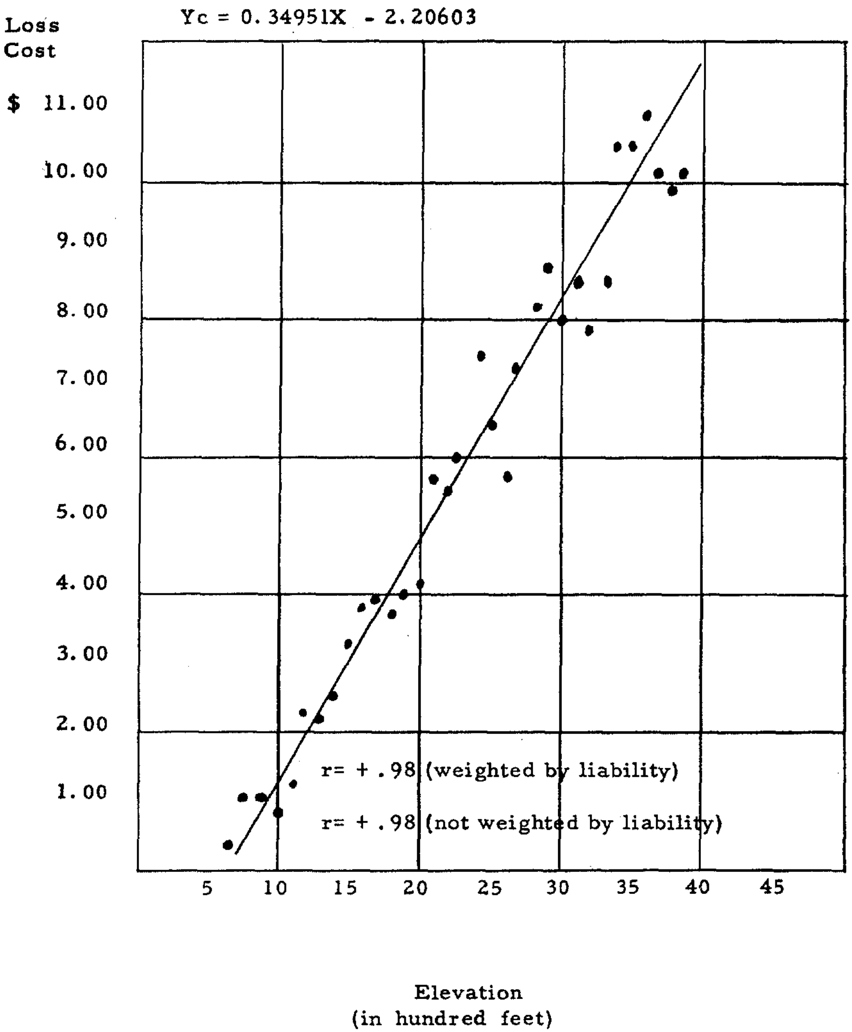

Chart 3. Loss Cost by Elevation Group, Kansas, 1924-1959. Each point represents the loss cost for all townships in that elevation group obtained by dividing the total losses of those township, 1924-1959, by the total liability of the same townships, 1924-1959.

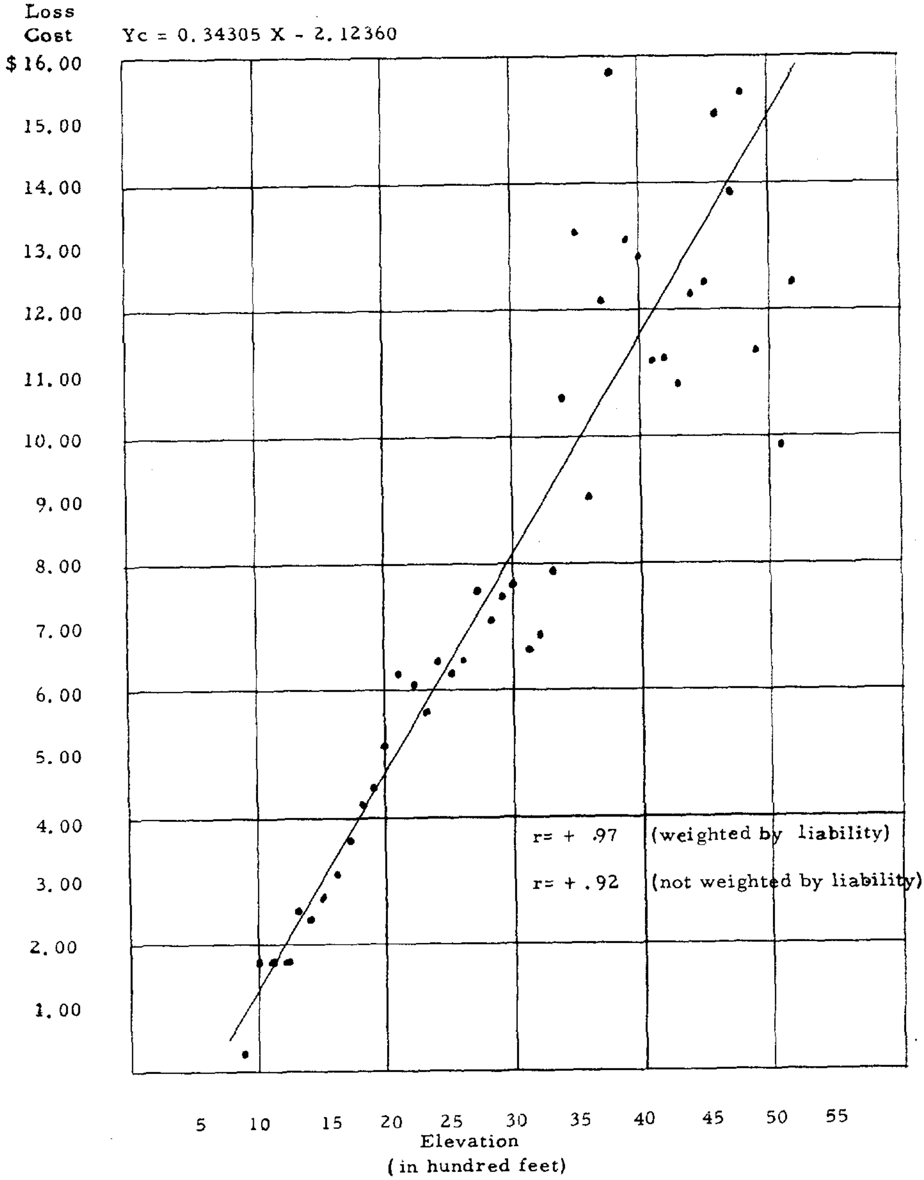

Chart 4. Loss Cost by Elevation Group, Nebraska, 1924-1959. For explanation see Chart 3.

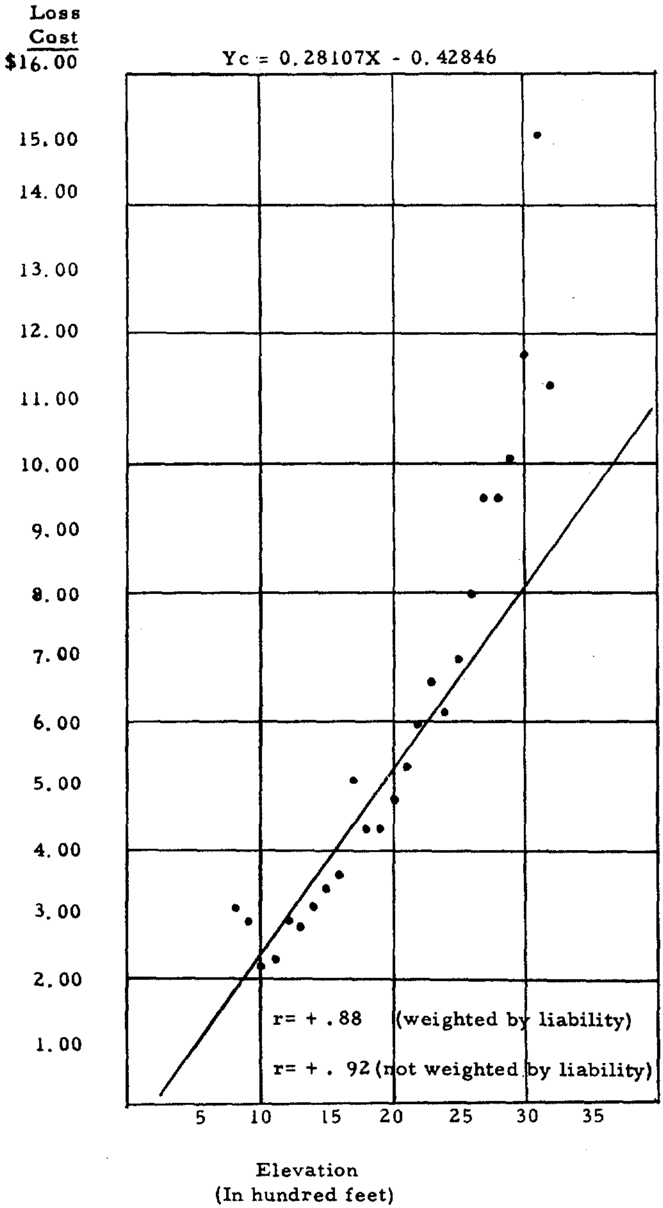

Chart 5. Loss Cost by Elevation Group, North Dakota, 1924-1959. For explanation see Chart 3. A curved line would appear to fit the data better, and would increase the correlation coefficient.

The introduction of county and township loss cost into the rating formula was done in an attempt to partially compensate for possible unknown variance, as well as to satisfy long-established customs in rating by not deviating too radically and too fast from former rating methods.

For Kansas then, the formula for base loss cost is as follows:

$$\text{base loss cost} = 25\% \times \text{individual township loss cost} + 25\% \times \text{county loss cost} + 50\% \times \text{elevation group loss cost}$$

Example: *Reno County, 26S, 8W.*

liability, 1924-1959	$1,534,062
converted losses, 1924-1959	53,080.25
individual township loss cost	$3.46

Reno County, all townships

liability, 1924-59	$50,717,707
converted losses, 1924-1959	1,938,542.68
county loss cost	$3.82

Elevation group 1600 ft.
(26S 8W is in this group)
see Table 1
computed elevation loss cost $3.39

$$\text{base loss cost} = (.25)\ (3.46) + (.25)\ (3.82) + (.50)\ (3.39)$$
$$\text{base loss cost} = \$3.52$$

This method of calculating the base loss costs using elevation as a major factor applies only to certain of the prairie states, although in these states 45% of the 1959 crop-hail United States premiums were written.

In the rest of the states base loss costs are derived in various other ways. For instance, in North Carolina the basic geographical area is county, and the basic crop is tobacco. The policy form to which the base rate applies is the annual percentage form. The conversion of losses is done in the usual manner, but the base loss cost for each county is calculated by simply dividing the accumulated losses over the years by the accumulated liability over the same period.

Many states use this method, and in the rest not using the elevation factor there are a few other variations as to the geographical area used. All of these calculate a base loss cost by the same method as used in North Carolina. There is little need to go into further details in these cases as it would add little to what has already been presented.

E. *Expense-Loading and Calculation of Required Base Rate*

The rate to be charged must include, of course, a loading to compensate the insurer for commissions paid to agents, taxes, and company disbursements including field, home office, and other overhead expenses. Loss adjustment expenses are not included in crop-hail insurance loss figures, so these too must be added. In addition the rate must allow for a fair gain from underwriting and a contribution for a catastrophe reserve.

The average commission paid by all companies varies between states, and by rate classification within certain states. Thus in Kansas for rates $10.00 and under per $100.00 of insurance, the average commission paid by companies is approximately 20%. For rates $10.00 to $15.00 it is 15%; and for rates above $15.00, 10%.

The other company expenses nationwide are estimated at 22% of the premium dollar, and the expected gain from underwriting and contribution to catastrophe reserve at 6%.

Thus, the rates as calculated must anticipate the following loss ratios in Kansas*:

Kansas Rates	*Anticipated Loss Ratio*
$10.00 and under	52%
$10.01 through $15.00	57%
$15.01 and over	62%

The required base rate is obtained by dividing the base loss cost by the anticipated loss ratio (expressed in decimal form). The formula is:

required base rate = base loss cost ÷ anticipated loss ratio

The required base rate is usually rounded to the nearest 20¢ below $4.00 to the nearest 50¢ between $4.00 and $8.00, and to the nearest $1.00 above $8.00.

In states with the extra harvesting expense allowance or fire coverage on growing crops, rates are established separately for these additional coverages. They are added to the required hail base rate (calculated to the nearest cent) and the resultant combined required rate is rounded as mentioned in the preceding paragraph.**

Example: Reno County, 26S, 8W

base loss cost $3.52

anticipated loss ratio 52%

required base rate = $\frac{3.52}{.52}$ + .20 (extra harvesting expense) + .10 (fire coverage)

required base rate = 6.77 + .20 + .10 = $7.07

rounded required base rate = $7.00

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* The average loss ratio anticipated for the entire United States is approximately 52%.

** In actual practice a table is used showing ranges of hail loss costs and giving the required rate in rounded form for each range.

F. *Development of Proposed Base Rate*

The calculation of *required* base rates provides the first stepping stone to the promulgation of new proposed rates. The base rates as proposed are not always the same as the required rate for the reasons indicated below:

1. *Judgment rates:* Many of the required rates are for areas where little business has been written, and, consequently, the base loss costs from which they are derived are neither representative nor significant. For instance in Nebraska there are 2179 townships for which required base rates are calculated. 1187 or 54% of these have had 97% of the total insurance written 1924-59. The other 992 townships account for only 3% of the insurance, and each individual township's base loss cost is meaningless due to the sparsity of data.

   Therefore, an arbitrary definition is established to designate "judgment" townships. The method now used consists of taking the cumulative amount of insurance over the period of record for each township. In Nebraska if this figure is under $150,000, the township is rated on "judgment" basis; if $150,000 or over, the township's proposed base rate is developed using all of the pertinent rules and formulas. The proposed base rate for a "judgment" township may be set at any figure, but usually rates of contiguous areas play a large part in its determination.

2. *Minimum and maximum rates:* Another factor which prevents the proposed rate from always equaling the required rate is the minimum and maximum rates set for each state.

   Even eliminating townships with small amounts of cumulative liability written, the required base rates range from very low figures to excessively high values for any state in question. It has been found necessary to establish a minimum base rate and a maximum base rate for each state. For example, in Kansas no proposed base rate may be less than $3.00 per $100.00 of insurance nor more than $20.00.

3. *Percentage limitations on rate changes:* During the development of a methodical method of crop-hail insurance rating, it became apparent that it was not possible from a public relations viewpoint to proceed from the present rate to the required rate in every case. Due to the catastrophic nature of crop-hail insurance this could well involve increases of rates ranging from 100% to 200%.

With regard to rate decreases the same problem did not manifest itself as the all-time loss cost with good experience drops rather slowly from year to year. However, the setting of a maximum percentage increase in rates necessitated that a corresponding maximum percentage decrease be set in order to keep the state-wide average rate at a proper level. To allow every rate decrease without limitation, and at the same time to restrict rate increases produces a constantly deteriorating rate level.

The rules of the Association in most township states provide that the maximum rate increase cannot exceed 60%, and the maximum rate decrease cannot be more than 30%. The relationship of 60% increase to 30% decrease has been developed from experience as that which is necessary to keep the rate level in balance.

A further development came at a later date. Situations developed where a devastating hailstorm resulted in required rate boosts of more than 100%. A rate boost of 60% was actually given and several years later at a subsequent rate revision, the required rate was still above the rate in effect. However, the experience had been excellent since the last rate revision, even to the point of no losses. At this time the insureds could well ask "Why do you plan another rate increase? Three years ago you raised my rate and we have had no losses since."

To answer this problem the loss ratio since last revision was introduced to influence the magnitude of rate increases and decreases. A bad loss ratio since last rate revision results in a maximum rate increase, a good loss ratio in a lesser increase, or possibly no increase at all.

Similarly, for rate decreases it does not appear sensible for rates to be reduced if a bad loss ratio has ensued since the last change in rates, even if the required rate is less than the present rate.

A further refinement in the percentage limitation table came about through consideration of the relationship of the required rate to the present rate. The further the spread between these two figures, the greater the need for rate adjustment. Consequently, the ratio of the required rate to the present rate was also made part of the table. If the required rate is considerably above the present rate, a larger rate increase is permissible than if they are close together. The same reasoning applies to rate decreases.

A percentage limitation table presently in use for Kansas is shown in Table 2.

A formal table is used only in states where base loss costs are calculated for each township. In states having rates set by county or area it has been found sufficient to use a somewhat less rigorous approach. A typical paragraph in the explanatory manual for a county-rated state reads:

"From a consideration of calculated required rates, amount of liability written over the period and in recent years, rates in effect during the past season, recent loss experience, etc., a rate is recommended for each area."

With a limited number of required rate and present rate combinations it is possible to apply in each individual case the same reasoning outlined above without having rigid rules.

With thousands of townships it is not possible to do this manually and a formal table is used which is adaptable to machine processing. (See Chart 6.)

4. *Exceptions to the rating system:* It is realized that no matter how comprehensive a rating system is, that there are occasions when the rates as determined are not considered as reliable. To take care of this contingency the rate system manuals of the various states have a provision whereby exceptions to the rating system may be made.

   The use of this device, however, must be watched carefully lest the use and acceptance of the rating method be damaged. Exceptions should be rarely made, and when made, supported with sound reasons.

Table 2. *Percentage Limitations on Rate Changes, Kansas, 1960 Filings*

Maximum Increases In Rates

Required Rate— % Higher than Present Rate:	*Loss Ratio Since Last Rate Revision:*	*Maximum Rate Increase:*
0-39%	0-49%	No increase
	50%-up	Increase to required rate
40-69%	0-29%	No increase
	30-49%	20%
	50-79%	40%
	80%-up	Increase to required rate but not more than 60%
70%-up	0-19%	No increase
	20-29%	20%
	30-49%	30%
	50-79%	50%
	80%-up	60%

Maximum Decreases In Rates

Required Rate— % Lower than Present Rate:	*Loss Ratio Since Last Rate Revision:*	*Maximum Rate Decrease:*
0-29%	0-29%	Decrease to required rate but not more than 10%
	30%-up	No decrease
30-59%	0-29%	20%
	30-59%	10%
	60%-up	No decrease
60%-up	0-29%	30%
	30-59%	20%
	60%-up	No decrease

Example: Reno County, 26S, 8W

premiums since last rate revision	$6,066.84
hail losses " " " "	$2,092.32
loss ratio " " " "	34.49%
present base rate	$7.50
required base rate	$7.00
% required rate lower than present rate	6⅔%
maximum decrease in rate permissible	no decrease permissible
Therefore, proposed base rate	$7.50

G. *Policy Form and Crop Factors*

The determining of the proposed rate accomplishes the second major step. The last stage in the production of the final rate schedule involves the expanding of base rates to cover all of the various crops, policy forms, and additional coverages (if any).

1. *Policy form rate factors*

To expand the base rate to apply to each policy form necessitates the determination of the policy form factor.

Where the amount of insurance written on other policy forms is small, the policy form factors are set by judgment. Increasingly, however, statistical analyses which have been developed are used, and these allow a more factual determination.

a. *Percentage loss summary:* One type of analysis involves taking each proof of loss and recalculating it as if another policy form applied. For instance, if a $1000 policy has a 30% loss under the Annual Percentage form, the total loss would be $300. However, if this had been an Excess over 10% Loss form, the loss would be 20% (30% — 10%) or $200. Under an Excess over 20% Loss Increasing Payment form the loss calculation would be (30% — 20%) × 1.25 = 10% × 1.25 = 12½% or $125.00.

Fortunately, we have detail loss records on magnetic tape, and computations are made rapidly. After the individual loss calculations are completed, computed losses are added for each policy form, and the total is expressed as a percentage of the base policy form. This, then establishes the basis for setting policy form factors.

You are able to go only from broader coverage policies to more restricted policies, not reverse. Thus, you may calculate Excess over 10% losses from Annual Percentage form losses, but you cannot compute Annual Percentage form losses from Excess over 10% losses. In the latter case you are missing those instances when the loss percentages are under 10%, and are not reported.

Another caution must be observed. There may be a bias in estimating Excess over 10% losses from Annual Percentage form data due to the human element in loss adjustments. It is not inconceivable that an inexperienced loss adjuster may tend to be more liberal in evaluating a damage to a crop which has an Excess over 10% Loss Endorsement covering, than when full cover attaches. Theoretically, this should not happen and scientific loss adjustment procedures minimize its occurrence, but mistakes and pressures do happen.

Usually the computations are restricted to the base crop, and the policy form relationships are assumed to hold state-wide. However, recently a summary was subdivided by rate area, and this brought out a close relation between rate level and the amount of credit which should be allowed for the excess over loss endorsements: the higher the rate, the less the percentage credit. The Kansas percentage loss summary is shown in Table 3.

b. *Policy form comparison:* Another method of determining policy form factors is to tabulate the actual experience of the various forms over the period

CROP-HAIL INSURANCE ACTUARIAL ASSOCIATION

RATE ANALYSIS

YEAR 1960 STATE Kansas BASED ON PERIOD 1924-1959 PREVIOUS ANALYSIS BASED ON PERIOD 1924-1958

State	County Code	County Name	Township	Range	Liability	▼ Elevation	Significant Years	Loss Ratio Since Last Analysis	Loss Cost: Township	Loss Cost: Elevation	Loss Cost: County	Loss Cost: Final Aver.	Rate: Required	J.R.	Rate: Present	Rate: Proposed
15	155	RENO	23S	6W	1663243	15	34		304	304	382	324	650		700	650
15	155	RENO	23S	7W	3366609	16	36		469	339	382	382	750		800	750
15	155	RENO	23S	8W	2627243	17	35		517	374	382	412	800		900	800
15	155	RENO	23S	9W	2259296	17	35		621	374	382	438	900		900	900
15	155	RENO	23S	10W	1067017	18	31		342	409	382	386	750		750	750
15	155	RENO	24S	4W	1484590	14	35	12	208	269	382	282	550		600	550
15	155	RENO	24S	5W	651306	15	27		153	304	382	286	600		650	600
15	155	RENO	24S	6W	1403126	16	34		347	339	382	352	700		800	700
15	155	RENO	24S	7W	2680218	16	35		548	339	382	402	800		900	800
15	155	RENO	24S	8W	2460110	16	36		333	339	382	348	700		750	700
15	155	RENO	24S	9W	809241	17	31		330	374	382	365	750		800	750
15	155	RENO	24S	10W	699217	17	31		220	374	382	338	700		750	700
15	155	RENO	25S	4W	2393790	15	36		222	304	382	303	600		650	600
15	155	RENO	25S	5W	1367269	15	34		306	304	382	324	650		700	650
15	155	RENO	25S	6W	917918	15	25		618	304	382	402	800		900	800
15	155	RENO	25S	7W	1151262	16	31	5	381	339	382	360	700		800	700
15	155	RENO	25S	8W	1850920	16	34	16	489	339	382	387	800		900	800
15	155	RENO	25S	9W	1742346	16	36		398	339	382	365	750		800	750
15	155	RENO	25S	10W	565945	17	27		189	374	382	330	650		700	650
15	155	RENO	26S	4W	1962988	15	34	10	294	304	382	321	650		700	650
15	155	RENO	26S	5W	1156402	14	29	2	227	269	382	287	600		600	600
15	155	RENO	26S	6W	655584	16	17		246	339	382	327	650		750	700
15	155	RENO	26S	7W	484767	16	14		152	339	382	303	600		700	650
15	155	RENO	26S	8W	1534062	16	36	34	346	339	382	352	700		750	750
15	155	RENO	26S	9W	2068150	17	36		313	374	382	361	750		800	750
15	155	RENO	26S	10W	959501	17	30		189	374	382	330	650		700	650
					50717707	*										
15	157	REPUBLIC	1S	1W	1112225	16	35	15	665	339	366	427	900		900	900
15	157	REPUBLIC	1S	2W	551321	16	28	131	662	339	366	427	900		900	900
15	157	REPUBLIC	1S	3W	750829	16	28	65	277	339	366	330	650		700	700
15	157	REPUBLIC	1S	4W	1226511	16	32	128	396	339	366	360	700		750	750
15	157	REPUBLIC	1S	5W	1315270	15	28	33	419	304	366	348	700		750	750
15	157	REPUBLIC	2S	1W	649127	15	31	69	145	304	366	280	550		600	600
15	157	REPUBLIC	2S	2W	752630	16	29	32	364	339	366	352	700		750	750
15	157	REPUBLIC	2S	3W	558039	16	27	53	322	339	366	342	700		750	750
15	157	REPUBLIC	2S	4W	1164204	15	31	9	336	304	366	328	650		700	650
15	157	REPUBLIC	2S	5W	1345107	15	31	5	344	304	366	330	650		750	700
15	157	REPUBLIC	3S	1W	747403	16	29	9	271	339	366	329	650		750	700
15	157	REPUBLIC	3S	2W	589545	16	27	8	251	339	366	324	650		700	650
15	157	REPUBLIC	3S	3W	466878	16	27		183	339	366	307	600		700	650
15	157	REPUBLIC	3S	4W	702888	15	26		300	304	366	319	650		700	650
15	157	REPUBLIC	3S	5W	1770731	15	31	2	286	304	366	315	650		700	650
15	157	REPUBLIC	4S	1W	963641	14	31		288	269	366	298	600		600	600
15	157	REPUBLIC	4S	2W	969246	14	28	5	627	269	366	383	750		800	750
15	157	REPUBLIC	4S	3W	978148	14	28	1	487	269	366	348	700		700	700
15	157	REPUBLIC	4S	4W	681058	14	24		374	269	366	320	650		650	650
15	157	REPUBLIC	4S	5W	1132036	15	32		196	304	366	293	600		650	600
					18426837	*										
15	159	RICE	18S	6W	902332	17	27		186	374	278	303	600		650	600
15	159	RICE	18S	7W	1157852	16	26		115	339	278	268	550		600	550
15	159	RICE	18S	8W	1199737	17	28		127	374	278	288	600		600	600

Chart 6. **A Sample Sheet of the Tabulating Machine Print-Out of Kansas Rate Analysis for the 1960 Season. All computations and application of rules are done by machine for the large township states.**

of record. It is necessary to classify the experience by rate area, and then to calculate the percentage relationship for each of these rate levels. The state-wide average is calculated as an average of the computed percentages. Generally, only the experience of the base crop is used.

Because the writings of crop-hail insurance tend to be concentrated in one policy form in a given area, the results of policy form comparison summaries have in most instances been disappointing. The percentage loss summary has produced much more useful results.

2. *Crop factors*

Different crops are assigned to crop classes according to degree of hail hazard. For instance, in Kansas there are about 85 crops divided into 7 crop classes (including a catch-all category for crops not specifically named in the schedule).

A crop factor is determined for each crop class. Again, as with policy form factors, where sufficient experience has not been accumulated, factors are set by judgment.

When ample experience is available, crop comparison summaries are able to be produced similar to the policy form comparison summaries mentioned above. Experience over the period of record for each of the major crops is classified by rate level. Ratios of the loss cost of each crop to the base crop loss cost are calculated for each level, and state-wide average calculated from the ratios.

In contrast to the policy form comparison summary, the results obtained from the crop summary have been most helpful. An example of a crop comparison summary is shown in Table 4.

Table 3. Percentage Loss Summary, Kansas, Wheat, 1951-1957

1958 Rate Area	Ann. % Form Loss Cost	XS 10 Basis Computed Loss Cost *	% of Ann. % Loss Cost	XS 20 IP Basis Computed Loss Cost *	% of Ann. % Loss Cost
$ 3.00	$ .62	$ .32	52%	$ .22	35%
3.25	1.00	.52	52	.37	37
3.50	1.09	.52	48	.36	33
3.75	1.28	.72	56	.53	41
4.00	1.44	.81	56	.62	43
4.50	1.48	.81	55	.57	39
5.00	2.37	1.40	59	1.09	46
5.50	2.17	1.31	60	1.07	49
6.00	2.54	1.55	61	1.26	50
6.50	2.20	1.27	58	.99	45
7.00	2.98	1.80	60	1.39	47
7.50	3.30	1.97	60	1.55	47
8.00	3.61	2.24	62	1.83	51
9.00	3.96	2.44	62	1.98	50
10.00	5.11	3.38	66	2.90	57
11.00	5.09	3.33	65	2.77	54
12.00	8.21	6.09	74	5.71	70
13.00	8.19	5.94	73	5.48	67
14.00	9.03	6.85	76	6.49	72
15.00	6.31	4.44	70	3.96	63
16.00	9.12	6.79	74	6.44	71
17.00	14.48	11.65	80	11.94	82
18.00	15.76	12.60	80	12.49	79
19.00	14.37	11.36	79	11.22	78
20.00	12.86	9.71	76	9.17	71
Entire State	$3.43	$2.27	66%	$1.96	57%

* Annual Percentage Form losses recalculated.

Table 4. Crop Comparison Summary, Iowa, 1948-56, Annual Percentage Form Data.

Rate Area (1956)	Liability: (Base Crop) Corn	Liability: Soybeans	Loss Costs: Corn	Loss Costs: Soybeans	Soybean Loss Cost as % of Corn Loss Cost:
$1.70	$ 4,340,869	$ 1,555,967	$ .41	$ .66	161%
1.80	5,878,712	636,343	.59	.71	120
1.90	2,894,013	322,528	1.54	2.99	194
2.00	32,456,646	5,189,834	1.21	1.87	155
2.25	9,994,709	2,398,391	.41	1.18	288
2.50	29,276,581	6,303,692	1.31	2.39	182
2.75	11,549,874	2,905,445	.88	1.93	219
3.00	35,609,334	7,768,493	1.59	3.94	248
3.25	17,103,137	3,452,644	2.15	4.48	208
3.50	6,294,437	562,976	2.97	5.93	200
3.75	9,628,456	1,897,193	2.46	5.64	229
4.00	18,954,985	3,135,948	2.54	4.79	189
4.50	6,346,325	958,415	2.22	4.82	217
5.00	7,705,188	1,282,665	3.29	5.17	157
5.50	2,502,851	610,351	3.17	6.03	190
6.00	1,537,098	463,523	1.65	3.29	199
7.00	26,318	7,163	5.96	12.60	211
7.50	1,891,194	577,006	4.59	8.45	184

Average Indicated Crop Factor- (Weighted by soybean liability) 204 % or 2.04

H. *Additional Coverages*

The basic crop-hail policy has additional coverages which are either included, or may be added on an optional basis, but these vary from state to state.

The extra harvesting expense allowance is included in many states. This provides for an additional loss award when the percent loss to the crop exceeds 70%. The rate for the extra harvesting expense feature is included at the time the required base rate is calculated.

Fire coverage on growing crops is part of the policy in most states, and, again, the rate is included in the calculated required base rate.

Kentucky, Tennessee, and North Carolina have available a policy form which gives protection to the harvested tobacco crop against the perils of windstorm, explosion, riot, riot attending a strike, civil commotion, and vehicles. This is in addition to the perils insured against in the standard crop-hail insurance policy, and coverage on the harvested tobacco cannot be written unless the growing crop is also insured against hail damage.

In this case a flat rate is added to the crop-hail rate, and the final rate is quoted in the rate schedule as a single, indivisible rate.

Similarly, there are 78 counties, situated in Illinois, Indiana, Iowa, Minnesota, and Ohio, for which an experimental coverage is offered against crop failure. Known as Crop Failure Insurance, it gives disaster protection, as a farmer must lose a substantial part of his normal crop before he is eligible to receive loss payment. The perils insured against include drought, excessive heat, flood, excessive moisture, insect infestation, plant disease, wildlife, wind, tornado, sleet, hurricane, frost, freeze, and snow; they are referred to as "B" perils, the "A" perils being those covered in the standard policy. This endorsement, which must be attached to a crop-hail insurance policy, has separate rates quoted and the premium is calculated as an additional amount to be paid along with the crop-hail premium.

I. *Preparation of Expanded Rate Schedule*

The expansion of the rate schedule to cover every crop and all policy forms involves multiplying the base rate for each location by the crop factor, rounding to the nearest 10¢; then multiplying these rates by the policy form factors, and again rounding.

Example: Reno County, 26S, 8W

Proposed base rate: $7.50

Crop class:*	Crop factor:	Annual % form proposed rate:
Class W	1.0	$ 7.50
Class D	1.5	11.30
Class E	2.0	15.00
Class F	2.2	16.50

* Only selected classes used for illustration.

Policy form factors:

Excess over 10% loss 0.71
Excess over 20%—increasing payment 0.62

	W	D	E	F
Ann. %	$7.50	$11.30	$15.00	$16.50
XS 10	5.30	8.00	10.70	11.70
XS 20-IP	4.70	7.00	9.30	10.20

Different ways are used for publishing the rates to be charged. In a state with townships a list of base rates by township is shown, and supplemental tables are used to determine the final rate according to location, policy form, and crop.

In other states where base rates are not so numerous, complete rate tables by location, policy form and crop are set forth which enables the agent to find the appropriate rate immediately.

One limitation is imposed on all schedules. A rate in excess of $24.00 is never quoted; a coverage requiring more than this is listed as "insurance not offered". Also, no rate less than $1.00 is quoted; and in this case, the schedule has a footnote stating that this is a minimum rate.

This, then, with several pages of rules and information, a table of contents and an index, constitutes the crop-hail insurance rate schedule.

IV. RESEARCH TO IMPROVE RATES

There are certain significant dates which stand out in the history of crop-hail insurance representing major steps forward in scientific rating:

1915. The first organized effort of hail-writing companies to gather statistics. The Western Hail and Adjustment Association was formed in this year, and statistics by county gathered.

1924. The realization that experience should be accumulated by geographical areas smaller than counties. Companies reported for certain major-writing states liability, premiums and losses by governmental township (6 miles by 6 miles).

1932. General revision of rating procedures to use township data. Arrangements made to accumulate data by use of tabulating machines. Policy forms and endorsements were clarified by including clauses as to methods of determining losses on specific kinds of crops.

1948. Crop-hail Insurance Actuarial Association started to gather crop-hail insurance statistics nationwide by location, policy form, and crop. Mathematical rating formulas devised and rating system manuals developed. Use of elevation areas: the first instance of using a *physical* classification instead of a strictly *location* classification.

If one would ask the most important difference between fire insurance rating and crop-hail insurance rating, the answer would be that "crop-hail insurance rates have been based on primarily *statistical* considerations, while fire insurance rates have been developed mainly from a consideration of *physical* factors."

This is not to disparage either method. Indeed, the reasons for the two approaches originated in the unique factors affecting the two types of insurance.

The Analytical System uses a physical classification method based on occupancy, exposure, structure, and protection. Much engineering knowledge was available in earlier days to enable predictions to be made as to which risks were more hazardous than others. On the other hand, the problem of collecting detailed statistics (especially without the aid of modern data processing systems) was enormous. Numerous parameters existed with the further complication that large amounts of insurance were written at specific rates, rather than at class rates. Schedule rating reduced considerably the number of homogeneous statistical units capable of being mathematically analyzed.

Therefore, the approach was primarily to set rates based on *physical* factors and then to use very general statistical data to evaluate total results.

The opposite situation prevailed in crop-hail insurance. Until 1948 there was no knowledge available to indicate why it hails more in one place than another. It was impossible to construct a crop-hail insurance rate schedule on an *a priori* basis. Only after experience was gathered was it possible to make rates in other than a blind, guessing way.

Fundamentally, then, fire insurance rates have an *a priori* emphasis (deduction of rates from principles assumed), while crop-hail insurance rates have an *a posteriori* emphasis (rates cannot be known except through experience).

Actually, the argument as to which is the best procedure is senseless. Improved scientific rating in either case requires a merging of the two approaches. A physical classification technique without subsequent verification of assumptions by detailed statistical data and analysis is just as faulty as blind reliance on statistical data where *real* differences cannot be distinguished from *random* differences.

The key to improved crop-hail insurance rating lies in the development of much additional meteorological knowledge with regard to why it hails more in one place than another.

The first important breakthrough achieved was the use of the elevation factor in the states to which it was applicable. The use of this physical classification *together with* the excellent statistical data gathered over the period 1924 to date has imparted a degree of stability to rates in those selected states not possible before. Examples of the close relationship of elevation to loss cost have already been given in Part III.

To date the elevation relationship has been found to apply only in the states of Kansas, Oklahoma, Nebraska, South Dakota, North Dakota, Minnesota, and Iowa. In all other rating territories with the exception of Illinois (see below), a statistical approach is the only one that we have had and have.

As mentioned, up until 1948 very little was known in meteorology with regard to hailstorms. Since that time, and especially within the last five years, the understanding of severe local storms of all kinds, including hail, has increased immensely. A number of scientists have become interested in hailstorms and the outlook for the future is encouraging. One of the main contributing causes of the rising interest in this field has been the constant encouragement of the Crop-Hail Insurance Actuarial Association. Both the Manager and Assistant Manager of the Association are professional meteorologists, and they have consistently kept the importance of hail alive in the minds of other meteorologists with whom they have come into contact.

A significant step was taken by the Association in 1957 when a research contract was negotiated with the Meteorology Division of the Illinois State Water Survey. Headed by a very competent meteorologist versed in the new field of "radar" meteorology, this unit has made many contributions to knowledge about severe local storms.

The Illinois State Water Survey's project includes not only a study of Illinois hailstorms, but the general understanding of hailstorms, and the relationship of the occurrence of these with topographical and other physical parameters. Even with very inadequate statistical experience (township data is only available in Illinois from 1948 on) a marked improvement in the Illinois rating system was made possible for 1960 as a result of their two years of study.

The research program of the Asociation was expanded in 1960 to include the study of two additional states.

Although the study of physical factors affecting the occurrence of hailstorms is the major need for improvement of the crop-hail rate structure, additional progress is also possible by using more advanced methods in the statistical analysis of the vast amount of accumulated crop-hail insurance statistics. To date only the simplest forms of statistical analysis have been used.

Increased use of measures of variance, correlation coefficients, and time series analysis will elucidate relations which are now obscured by the mass of data.

The "normal curve" assumption of conventional statistics, however, does not fit crop-hail insurance data well. Much work will be needed to develop proper techniques to handle the extremely "skewed" nature of hail loss costs. Gumbel's* work on statistics of extremes will be useful in this regard.

Multiple correlations to develop the various interrelations between the variables affecting hail hazard will need to be developed and expanded. Orthogonal polynomials, successfully used in other meteorological applications, is another powerful tool.

V. OTHER FACTORS AFFECTING CROP-HAIL INSURANCE RATING

Even if there were no other considerations involved in determining hail hazard, the task of evaluation of the meteorological and statistical information would be most difficult. In reality, other factors complicate the development of sound rate structures.

* E. J. Gumbel, *Statistics of Extremes,* Columbia University Press, New York, 1958.

A. *Regulation by States*

As with other lines of insurance, all crop-hail insurance rates are subject to the approval of the various Insurance Departments.

Experience has shown that on the whole this has not proven to be hurtful. Indeed, the necessity for providing detailed supporting data many times improves recommendations which might otherwise be based on less conclusive assumptions. But it is a fact that pressure from agents and the public may adversely influence the decisions of regulatory bodies.

The use of current information in rate-making offers an opportunity to minimize unreasonable objections to needed rate increases. Proposing a rate increase immediately following a disastrous experience is to present your case under the most favorable circumstances. The losses are fresh in the minds of the insuring public, and the regulatory body has a minimum of protests to consider.

If your statistical experience is a year behind, however, the climate is no longer favorable. Besides losing the amount of increase for the period of one year, the intervening season may well have been a most profitable one. Even if long-term experience indicates a substantial rate increase is justified, it is much more difficult to successfully attain this. The proper level of the rate structure cannot be maintained if proposed increases are consistently scaled down.

B. *Acceptance of Rates by Insuring Public*

That the insuring public does not protest rate changes to regulatory authorities is important, but even more so is that they realize the equity of the rating and continue to purchase adequate amounts of protection.

A program of current rating accomplishes this aim, and especially so when considerations of loss ratio since last analysis are made part of the system of rate changes (see Part III). Required rates are based on all-time experience, but proposed rates take into account whether the experience in the area under consideration has been favorable or unfavorable since the last time the rates were promulgated. To raise rates after good experience causes resentment, to lower rates after adverse experience suggests irresponsible action in the farmer's mind. Again, if statistics are a year behind, a further complicating factor is introduced when a good season follows a bad season.

C. *Competition*

Vigorous competition exists in crop-hail insurance. Although there tends to be more in one area than another, being somewhat less in very high hazard regions, there exists a constantly balancing safeguard to excessive rates, even if there were a desire to charge such, and even if there were no regulatory agencies.

Rate structures which most adequately fit the actual existing degrees of hazard are potent competitive weapons. If the rate is not in accord with the risk, adverse selection and "skimming the cream" by competitors will lead to steadily worsening loss ratios. On the other hand, if your competitors are charging too much in some areas, and too little in other areas, judicious underwriting will protect your position.

D. *Weather Cycles*

Speculation on changing weather has probably existed since *Homo sapiens* first became established as a unique species. A favorite question asked today: "Is our weather changing?" must be answered "yes". Our weather is changing over the millenniums, the centuries, the decades, from year to year, day to day, and hour by hour. Some of these changes are rapid, some slow, some hardly perceptible.

But from a practical point of view the crop-hail insurance industry is concerned with the weather here and now, and for a short span of years ahead. In this aspect the weather can be considered as not changing fast enough to matter.* Climatological records give ample proof that our average weather measured over periods of tens of years changes but slowly.

This does not mean that there is no difficulty in estimating the proper level of the rate structure necessary to provide an equitable return. In "catastrophe" insurance the magnitude of the long term mean is determined by the loss experience occurring in a relatively few years out of the many years of record. When we have had 100 years of crop-hail experience, will it then be evident that our general average of rates now is 10% or 20% too low?

The application of the newer statistical techniques such as the "extreme-value" theory may help us obtain a more satisfactory answer than we now possess. An adequate "catastrophe reserve" loading, subject to change as our knowledge increases, will also minimize the consequences of a general inadequacy of rate levels.

E. *Weather Modification and Hail Suppression*

The Advisory Committee on Weather Control, established by act of Congress in 1957, was directed to make "a complete study and evaluation of public and private experiments in weather control for the purpose of determining the extent to which the United States should experiment with, engage in, or regulate activities designed to control weather conditions." The report** was completed and transmitted to President Eisenhower on December 31, 1957.

The Committee surveyed the present status of knowledge in the area of cloud physics and weather modification. It was their conclusion that there was some theoretical basis, but insufficient experimental proof, for the suppression of hailstorms. Unfortunately, due to concentration on other major aspects of weather modification, the Committee was unable to pursue projects directly designed to evaluate the effectiveness of hail suppression techniques. They did, however, produce a special study entitled "Survey and History of Hail Suppression Operations in the United States" (published in Volume II

* Time series analyses, however, may reveal a tendency for persistence of certain patterns of general weather circulation and which may result in a greater probability of a bad hail year following a bad hail year, than vice versa. However, this is in the realm of speculation as no positive proof has been produced to date.

** *Final Report of the Advisory Committee on Weather Control,* Volumes I and II, Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

of their report) which states "although proving nothing *per se,* the fact remains that not only does there exist a definite desire to actively combat hail on the part of the subscribers but that once a project has been in operation it apparently has been deemed sufficiently worth-while to be continued in subsequent seasons." The report also expresses the opinion that "the importance of effective hail suppression to the economy of the country cannot be overestimated." It goes on to say that it is hoped that data would be forthcoming from the many hail suppression projects in existence (35 during the period 1949-57).

The Committee also published in Volume II a technical report entitled "A Method for the Evaluation of Hail Suppression" which presents a program for statistical testing.

Neither confirming nor denying evidence as to efficacy of hail suppression was produced by the Committee; only the conclusion that there was a theoretical basis for expecting hail suppression to work. The best attitude for the insurance industry to maintain is an open-minded one, hoping that more positive proof will become available in future years.

VI. CONCLUSION

It should be emphasized that the principles of rate-making which have been set forth are generalized, and exceptions may be found in almost every state. Knowledge of the general system, however, will allow one to take any of the state rating system manuals and to master it quickly.

The necessity for merging statistical techniques and meteorological information has been dwelt on at length. In closing, the following statement taken from an earlier article of the author's is still as *apropos* today as when written in 1948:

"The object of the meteorological-statistical program is to elucidate the underlying principles that determine relative hail damage, and thus be able to develop a rate for each location and type of crop that will be in direct proportion to its risk from hail damage. In order to accomplish this it is necessary to correlate meteorological and physical factors with the accumulated insurance experience. Differences in hail damage from location to location must be explained by physical reasons in order that we may have confidence that the difference is real and not random."

"Research work along these lines is now being carried out. In addition, contact is being maintained with various outside authorities and agencies for assistance and information."

"The problems which are to be solved in the field of crop-hail insurance are complex, and steps toward their solution must be from many directions. These steps are now being taken."