# EVALUATION OF A NORTH DAKOTA HAIL SUPPRESSION OPERATION

(Preliminary Report)

By

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## INTRODUCTION

In 1946 Vincent Shaefer and Irving Langmuir discovered that certain types of clouds could be changed and since that time a variety of attempts have been made at weather modification. One such attempt has been the suppression of hail by cloud seeding. The coverage on hail suppression projects increased from 400 to 6750 square miles between 1949 and 1957. Since 1957 however many of the original projects have been reduced or discontinued. One project is currently being conducted in western North Dakota by two ranchers using two T6 aircraft equipped with airborne silver iodide generators and several ground generators. In 1961 and 1962 this operation covered approximately 600 square miles, and in 1963 it was expanded to include all of Bowman County and part of Slope County, an area of some 1500 square miles. These counties are in an area of high hail occurrence, with the average annual hail losses for each county nearly a quarter of a million dollars, and the insurance premiums for hail protection ranging as high as eighteen per cent. The purpose of the project, which is financed by contributions, is to reduce hail damage during the daylight hours. The sponsors of this project have not made an extensive evaluation of the operation and it is believed that such a study should be made. The purpose, then, of this investigation is to determine if significant changes resulting from the North Dakota hail suppression operation can be detected.

This preliminary report will review the work completed during the summer of 1964 while the author was on a ten week Research Participation Program sponsored jointly by the National Science Foundation and Colorado State University. It is anticipated that another report will be prepared after additional data not yet available to us have been analyzed.

## PROCEDURE

To evaluate this operation considerable background information had to be collected. Geographical information was obtained from U.S. Geological Survey quadrangle maps; land use figures from the Soil Conservation Service and the State Extension Service; and hail loss statistics from the Crop-Hail Insurance Actuarial Association (CHIAA) and the North Dakota State Insurance Department.

It is believed that if significant differences resulting from seeding are present they should be observable in one or all of the following parameters which are being considered in this study.

a) Per cent loss due to hail

b) Number of acres damaged by hail

c) Number of hail storms

d) Number of days with hail

It was decided that a target-control analysis with a regression line would be an appropriate evaluation for this commercial type hail suppression operation. A discussion of target-control analysis and how it works is presented in the next section of this report.

To date we have collected necessary background information and data, set up the analysis, put all data on punched cards, and programmed the evaluation for a digital computer. Work yet to be accomplished includes running the programs to obtain results, an analysis of these results, formulation of conclusions, and the preparation of a final report.

## DISCUSSION

In the target-control type analysis two areas must be considered. The area which is seeded is called the target area, while a second unseeded area

is referred to as the control area. The control area is selected so that it will be as much like the target area as possible. When the hailfall is heavy on the target it is desirable that it be heavy on the control, and when it is light on the target it should also be light on the control area. If the areas are exactly alike the statistician would say the areas are "highly correlated." This would be the ideal case and it could be represented as shown in Figure 1. The points in a diagram such as Figure 1 represent some type of hailfall data for some suitable time period. In the ideal case all of the points lie on a straight line called the "regression line". If we know the per cent loss (or any other variable we are considering) for the control area we can use a diagram such as Figure 1 to determine the per cent loss we would expect on the target area, assuming, of course, there had been no seeding on the target. Using Figure 1 we see that with a 10 per cent loss on the control area we would normally expect an 8 per cent loss on the target area, which is indicated by point A.

If cloud seeding is effective in reducing hail damage, under seeded conditions, we would expect to find a decrease in the per cent loss on the target, but not on the control. Referring again to Figure 1, if the control area experienced a 15 per cent loss we would normally expect a 12 per cent loss on the target area. If, however the target area had been seeded and it experienced only a 4 per cent loss, we would conclude that the seeding caused this difference. This difference is represented graphically by the distance between points B and C.

The actual situation, although similar to the ideal case outlined above, does present some difficulties. Perhaps the greatest problem arises

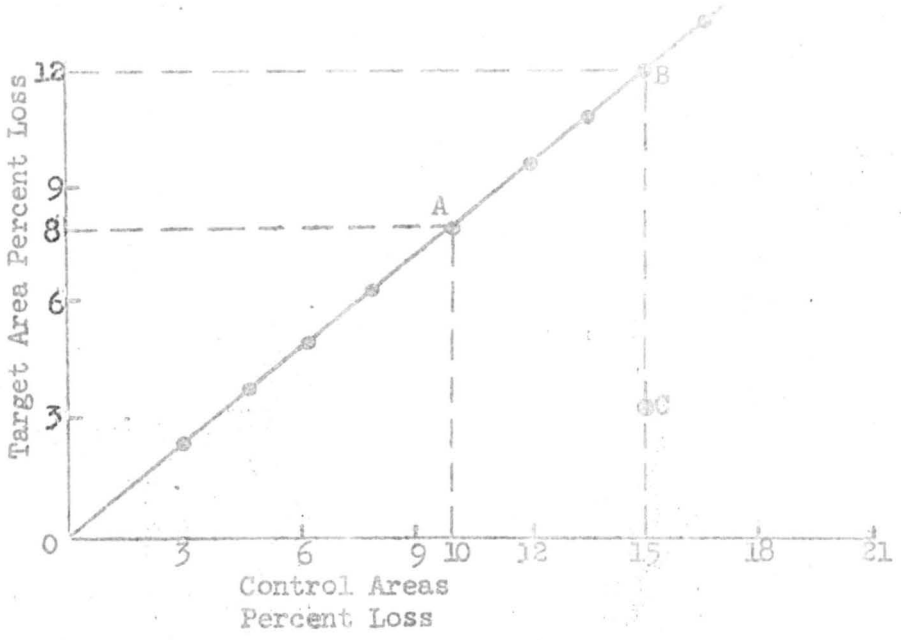



Figure 1. A plot of the per cent loss due to hail over a control and a target area in an ideal case.

because no two areas are exactly alike and thus the data do not lie on a straight line but are grouped more as shown in Figure 2. In cases such as these the "best" line is drawn through the points and is thought of as representing average conditions. With the target-control type analysis this line is our best estimate of the relationship which exists between the target and control areas with respect to the hailfall data. The more scattered the data the poorer the correlation (as relationship) and the less sure we are of the conclusions we formulate.

RESULTS

Figure 3 through 6 are examples of diagrams used in target-control type analyses. These results are taken from a target and control area whose correlation coefficients have not yet been computed. The regression lines have been estimated and thus the results are very tentative and are presented

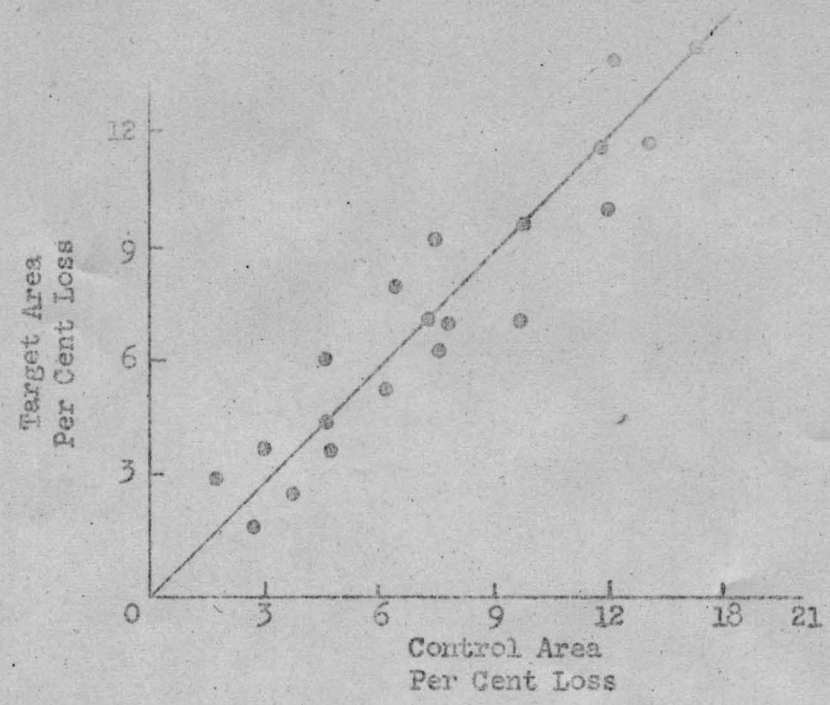



Figure 2. A plot of per cent loss due to hail over a control and a target area in an actual case.

here primarily to give examples of the type analysis being used in this study. Results based upon regression lines computed by the least squares method will be presented in the next report on this investigation.

Figure 3 and 4 represent the target-control relationship for per cent loss. This hailfall parameter is computed by dividing the total hail losses allowed by the total liability written and multiplying that result by 100. In Figure 3 each point represents one year's data for a given period, either day or night, while each point in Figure 4 represents a month's data for a given period.

In Figures 5 and 6 the parameter being considered is the number of acres totally damaged by hail. It is computed by multiplying the number of

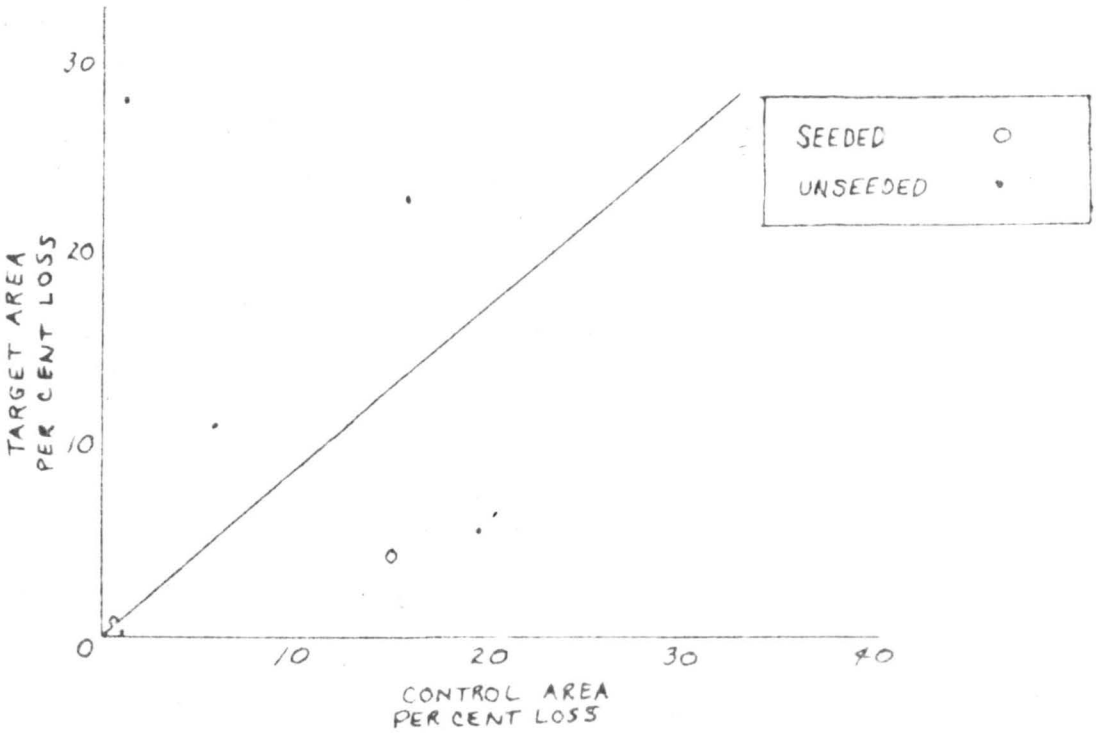



Figure 3. A plot of per cent loss for target and control areas. Each point represents one year's data.

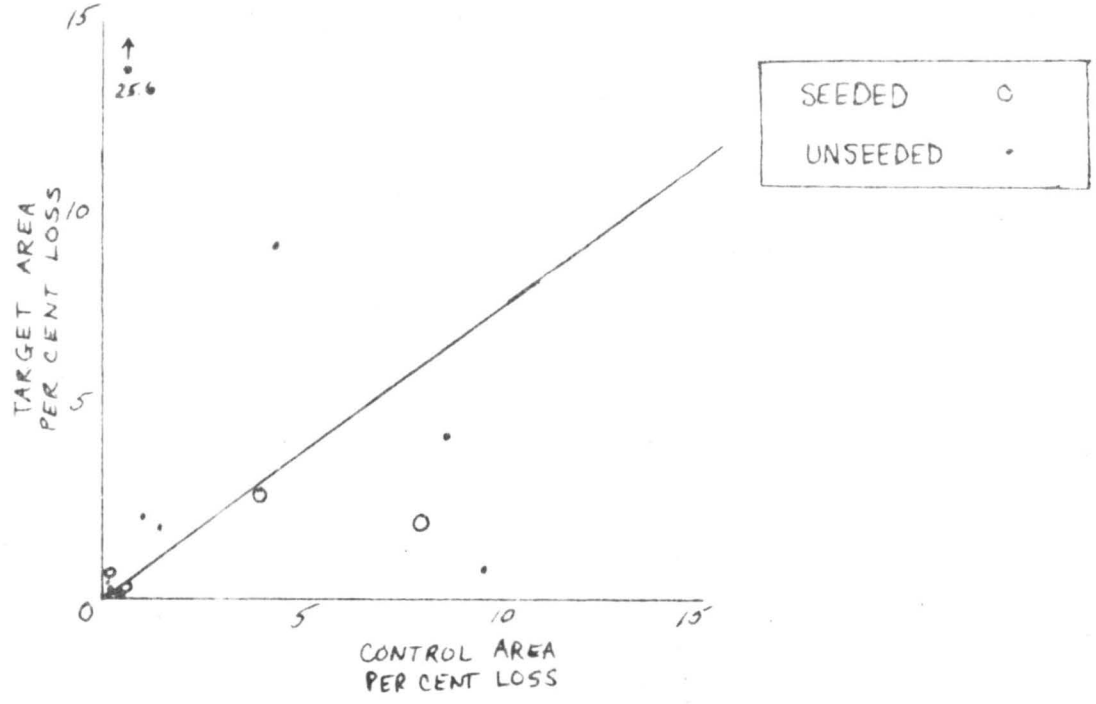



Figure 4. A plot of per cent loss for target and control areas. Each point represents one month's data.

acres damaged by the per cent of damage. As above, each point in Figure 5 represents a year's data while an equivalent point on Figure 6 represents one month's data.

The data from figures 3, 4, 5, and 6 suggest that the hail damage for the seeded cases may have been lower than that which would have been predicted by the regression diagrams. However, since the regression lines were drawn by estimate only, no significance can as yet be attached to these results.

The background information collected for this study is presented in the Appendices. The tables are self-explanatory so I will comment only briefly upon the most important points.

Table 1 is a statistical summary of hail loss data obtained from the North Dakota State Insurance Department. Of particular interest are the per cent loss averages of 14.4 and 18.0 for Bowman and Slope Counties compared to a statewide average of 7.2, and to an average of 13.9 for the area in northeastern Colorado where hail suppression experiments by Dr. R. A. Schleusener are now being conducted.

The weather summary for the southwestern section of North Dakota, presented as Table 2, indicates that during the summer of 1961 the area suffered a severe drought with precipitation approximately 50 per cent of normal.

Table 4 is a summary of the characteristics found in the target and control areas used in this report. It is important to note that the variation in size and per cent loss between these areas is less than 10 per cent while the difference in per cent of cropland is slightly over 20 per cent. Thus it would appear that these two areas are quite similar in nature.

Table 5 presents a comparison of the amount of insurance written in Bowman and Slope Counties by commercial companies, (CHIAA data) and by the state insurance department.

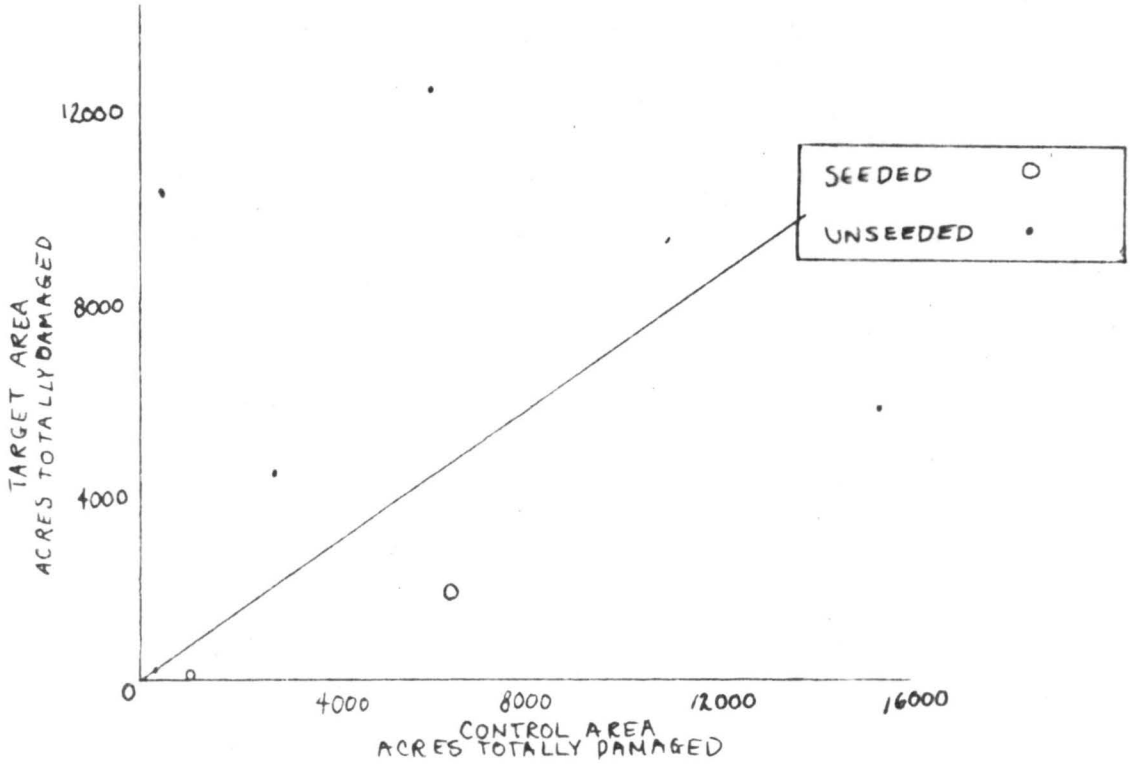



Figure 5. A plot of acres totally damaged for target and control areas. Each point represents one year's data.

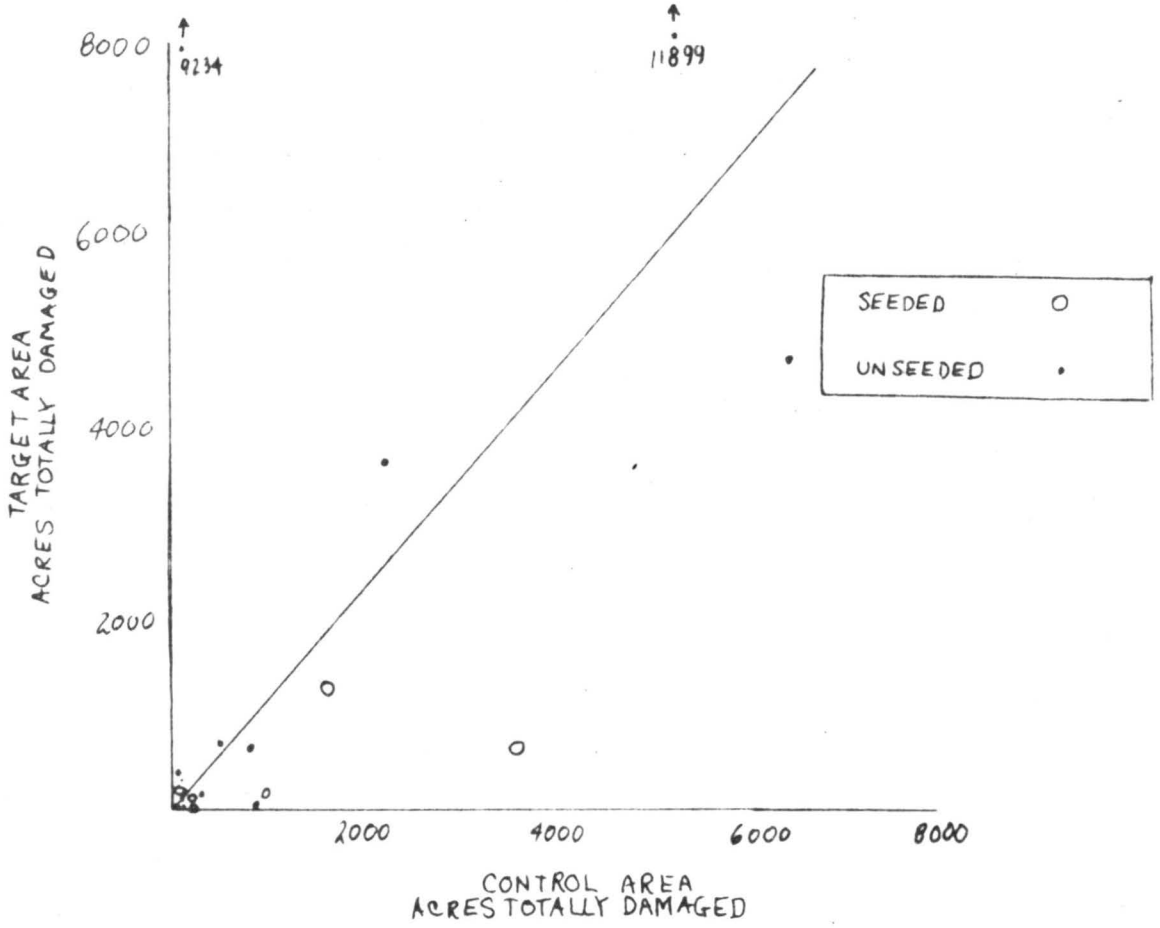



Figure 6. A plot of acres totally damaged for target and control areas. Each point represents one month's data.

Table 7 is a summary of the seeding information available from the flight logs of pilots Wilbur Brewer and William Fisher. Of particular interest are the seeding time totals of 8 hours, 16 hours, and 35 hours for 1961, 62, and 63. Also significant are the nearly 200 hours of operation logged on 21 ground generators in 1963.

Table 8 presents a summary of hailstorms in 1960 through 1963. It is interesting to note that the number of storms varied from a low of 6 in 1961 to a high of 36 in 1963, and that on the average 56 per cent of the storms occurred between the hours of 0500 and 2100 (9:00 P.M.).

A flight log was developed to standardize and significantly increase the amount of available flight and seeding information. Such data is of great importance in an evaluation of this type. The log was developed with the pilot in mind and it is hoped that a flight log will be completed on each of the seeding flights.

Figure 7 shows the per cent of cropland in each township of Bowman and Slope Counties. The appearance of much higher percentages in the eastern part of these counties is of particular interest.

Figure 8 presents historical hail loss data on a township basis. It is worth noting that significantly less insurance is written in the western part of these counties, which is largely rangeland.

## CONCLUSIONS AND RECOMMENDATIONS

Since this evaluation has just begun, no conclusive results are yet available, and firm conclusions have not been formulated. The preliminary and tentative results obtained to date lend optimism to the project and suggest that we should continue with the evaluation.

It is recommended that this study be continued until the hail suppression operation is terminated or until firm conclusions as to its effectiveness are obtained.

It is further recommended that correlation coefficients for several areas near the target be computed and the best of these areas be selected for the control. Additional historical data should be obtained from CHIAA and analyzed along with data currently available to give a better relationship between target and control. Regression lines should be computed by the method of least squares if there is sufficient linear correlation. Parameters such as the number of hail storms and the number of days with hail should be studied before firm conclusions are formulated. Collection and analysis of CHIAA and North Dakota State Insurance Department data should continue until firm conclusions as to the effectiveness of the project are established.

Finally, it is recommended that the flight log be reproduced and distributed in quantities sufficient to allow the use of one log for each seeding flight. These logs should be collected or submitted for analysis at regular intervals.

# APPENDIX A

Tables

TABLE 1. HISTORICAL DATA FROM NORTH DAKOTA STATE INSURANCE DEPT.

| Year | No. of Policies Written Annually | | Amt. of Liability Written Annually | | Total Hail Losses Paid Annually | | Percent Loss | | Percent of Ins. Acres Which Were Damaged | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Bowman Co. | Slope Co. | Bowman Co. | Slope Co. | Bowman Co. | Slope Co. | Bowman Co. | Slope Co. | Bowman Co. | Slope Co. |
| 1944 | 937 | 727 | 771,585 | 662,237 | 10,838 | 48,399 | 1.40 | 7.31 | 14.4 | 20.6 |
| 1945 | 837 | 664 | 737,687 | 634,032 | 791 | 23,244 | 0.11 | 3.67 | 4.4 | 22.9 |
| 1946 | 1011 | 703 | 972,729 | 710,257 | 170,991 | 102,185 | 17.49 | 14.39 | 56.3 | 42.2 |
| 1947 | 1379 | 950 | 1,455,344 | 1,070,593 | 174,467 | 189,193 | 10.99 | 18.96 | 38.9 | 87.5 |
| 1948 | 1615 | 1227 | 1,742,826 | 1,422,451 | 121,777 | 215,957 | 6.64 | 16.14 | 33.3 | 28.4 |
| 1949 | 1115 | 824 | 1,260,803 | 1,029,379 | 143,532 | 261,827 | 10.40 | 24.49 | 20.8 | 68.2 |
| 1950 | 1162 | 1040 | 1,167,045 | 1,161,165 | 18,682 | 54,964 | 1.71 | 4.46 | 11.6 | 22.8 |
| 1951 | 1355 | 1124 | 2,004,473 | 1,916,499 | 116,662 | 85,080 | 5.82 | 4.52 | 25.9 | 28.5 |
| 1952 | 1027 | 712 | 1,629,552 | 1,394,101 | 54,192 | 359,802 | 3.34 | 26.0 | 8.8 | 39.3 |
| 1953 | 1255 | 1075 | 2,020,054 | 1,952,474 | 470,583 | 300,843 | 23.94 | 14.65 | 69.6 | 44.8 |
| 1954 | 1246 | 954 | 1,777,778 | 1,580,928 | 386,985 | 160,010 | 21.74 | 10.45 | 94.7 | 46.2 |
| 1955 | 983 | 910 | 1,295,278 | 1,360,773 | 160,630 | 341,628 | 12.47 | 24.57 | 38.9 | 72.1 |
| 1956 | 446 | 598 | 520,487 | 947,464 | 217,529 | 870,603 | 40.98 | 91.70 | 68.7 | 98.2 |
| 1957 | 432 | 787 | 1,149,959 | 1,321,554 | 108,144 | 141,549 | 9.40 | 10.71 | 47.9 | 39.0 |
| 1958 | 762 | 774 | 917,990 | 1,252,461 | 345,425 | 42,330 | 37.63 | 3.38 | 55.3 | 20.0 |
| 1959 | 766 | 721 | 1,111,440 | 1,153,811 | 7,710 | 13,336 | 0.69 | 1.16 | 4.4 | 12.3 |
| 1960 | 752 | 773 | 1,048,561 | 1,214,619 | 305,564 | 194,477 | 29.14 | 15.66 | 69.6 | 49.3 |
| 1961 | 529 | 613 | 463,642 | 830,634 | 4,187 | 13,285 | 0.90 | 1.60 | 9.3 | 12.6 |
| 1962 | 740 | 728 | 942,554 | 988,428 | 250,824 | 418,226 | 26.61 | 42.31 | 65.1 | 96.4 |
| 1963 | 27 | 11 | 38,382 | 8,895 | 8,125 | 3,037 | 21.17 | 34.14 | 101.8 | 85.8 |
| Average For Co. | 918 | 696 | 1,077,366 | 1,056,294 | 147,303 | 182,034 | 14.74 | 18.85 | 43.9 | 47.5 |
| Average For No. Dakota State | 18,596 | | 20,858 | | 1,498,028 | | 7.17 | | 25.5 | |

TABLE 1. Cont'd

| Year | Percent of Policyholders Reporting Loss | | Percent of Twp. Reporting Losses | | No. of Acres Per Policy | | Liability in Dollar Per Policy | |
|---|---|---|---|---|---|---|---|---|
| | Bowman Co. | Slope Co. | Bowman Co. | Slope Co. | Bowman Co. | Slope Co. | Bowman Co. | Slope Co. |
| 1944 | 15.7 | 23.8 | ---- | ---- | 109.4 | 120.3 | 823.5 | 910.9 |
| 1945 | 3.9 | 23.2 | 30.1 | 67.6 | 116.1 | 125.7 | 881.3 | 954.9 |
| 1946 | 59.6 | 43.8 | 88.9 | 61.8 | 123.1 | 130.0 | 962.2 | 1013.0 |
| 1947 | 41.8 | 80.3 | 83.3 | 85.3 | 132.4 | 138.9 | 1055.4 | 1126.9 |
| 1948 | 26.6 | 28.8 | 83.3 | 82.3 | 132.9 | 140.5 | 1079.2 | 1159.3 |
| 1949 | 34.7 | 68.9 | 86.2 | 85.2 | 142.0 | 154.9 | 1130.8 | 1249.2 |
| 1950 | 12.4 | 22.2 | 61.1 | 50.0 | 124.9 | 137.6 | 1004.3 | 1116.5 |
| 1951 | 30.1 | 29.5 | 83.3 | 73.5 | 145.6 | 159.4 | 1479.3 | 1705.0 |
| 1952 | 10.9 | 47.0 | 41.7 | 70.6 | 147.6 | 176.3 | 1586.7 | 1958.0 |
| 1953 | 61.9 | 28.8 | 88.9 | 64.7 | 142.9 | 160.8 | 1609.6 | 1816.3 |
| 1954 | 98.4 | 54.9 | 94.4 | 82.3 | 126.4 | 145.1 | 1426.8 | 1657.2 |
| 1955 | 36.6 | 71.6 | 83.3 | 79.4 | 116.8 | 130.2 | 1317.7 | 1495.4 |
| 1956 | 83.6 | 97.6 | 75.0 | 67.6 | 101.6 | 131.9 | 1167.0 | 1545.6 |
| 1957 | 99.5 | 42.4 | 72.2 | 79.4 | 226.3 | 141.2 | 2661.9 | 1679.2 |
| 1958 | 52.9 | 20.0 | 97.2 | 61.8 | 102.5 | 135.9 | 1204.7 | 1618.2 |
| 1959 | 4.7 | 8.1 | 25.0 | 38.2 | 123.1 | 133.9 | 1450.9 | 1600.3 |
| 1960 | 73.3 | 51.7 | 80.6 | 79.4 | 118.9 | 134.3 | 1394.4 | 1606.2 |
| 1961 | 69.9 | 1.1 | 25.0 | 41.2 | 73.6 | 113.4 | 876.4 | 1355.0 |
| 1962 | 71.9 | 100.0 | 86.2 | 76.5 | 107.3 | 113.1 | 1273.7 | 1357.7 |
| 1963 | 88.8 | 81.8 | 30.5 | 8.8 | 95.3 | 80.0 | 1421.0 | 808.0 |
| Average For Co. | 48.9 | 46.3 | 69.4 | 66.3 | 158 6 | 135.2 | 1290.4 | 1386.2 |
| Average For No. Dakota State | 25.6 | | 83.0 | | 123.0 | | 1,178.0 | |

TABLE 2. WEATHER SUMMARY NORTH DAKOTA AREA

| Month | Year | General Remarks | Precipitation in Inches | Temperature (dept. from normal, °F) |
|---|---|---|---|---|
| April | 1960 | Warm weather, highest flood ever, dust-storm 13-14th | 1 | +3 |
| May | 1960 | Light flooding | 2 | +2 |
| June | 1960 | Jan-June precip. record least for period since 1908 | 2 | +1 |
| July | 1960 | Hot and dry | 0.5 | +4 |
| Aug. | 1960 | Warm | 2 | +1 |
| Sept. | 1960 | Hot and dry | 0 | +3 |
| Summer | 1960 | Weather generally hot and dry | 8 | +2-+3 |
| April | 1961 | Long drought ended April 20th. Area dry | 1 | -4 |
| May | 1961 | Dry weather - soil moisture deficient. Precip. 56% of normal from Jan-May | 1 | +1 |
| June | 1961 | Hot and very dry | 1 | +7 |
| July | 1961 | Drought broken July 10th. Cooling weather appears | 2 | 0 |
| Aug. | 1961 | Warmest and driest August | 0.5 | +6 |
| Sept. | 1961 | 1.5" of snow. Coldest Sept. | 3 | -7 |
| Summer | 1961 | Hot and dry - drought - precipitation 50% of normal | 8 | +5 |
| April | 1962 | Hot and dry - new early season records - 91° on the 24th | 1 | +4 |
| May | 1962 | Wet month - new May records | 6 | 0 |
| June | 1962 | Warm, moist month | 4 | +2 |
| July | 1962 | Coolest July since 1915 | 4 | -5 |
| Aug. | 1962 | Wet | 1 | -1 |
| Sept. | 1962 | Cool and dry | 1 | -2 |
| Summer | 1962 | A cool, wet summer | 17 | -2 |
| April | 1963 | | 2 | -1 |
| May | 1963 | Cool 14° on 22nd. Tornado in area | 2 | -1 |
| June | 1963 | Warm and wet | 4 | +1 |
| July | 1963 | Warm and wet month | 3 | +1 |
| Aug. | 1963 | Warm | 1 | +1 |
| Sept. | 1963 | Hot and wet | 1 | +6 |
| Summer | 1963 | A warm, wet season | 13 | +2 |

[1]Data from Weatherwise Magazine. Published by American Meteorological Society, 45 Beacon Street, Boston 8, Mass.

TABLE 3. TYPES OF CROPS INSURED BY NORTH DAKOTA STATE INSURANCE DEPT.

| Year | BOWMAN COUNTY | | | | | | |
|---|---|---|---|---|---|---|---|
| | Wheat | Barley | Oats | Flax | Rye | Corn | Other |
| 1942 | 69.1* | 15.4 | 5.8 | 3.6 | 5.6 | .4 | .1 |
| 1943 | 65.9 | 17.6 | 6.3 | 8.0 | 1.2 | .9 | .1 |
| 1944 | 73.2 | 16.5 | 6.9 | 1.9 | .8 | .6 | .1 |
| 1945 | 70.8 | 16.3 | 6.6 | 5.6 | .4 | .5 | .1 |
| 1946 | 73.3 | 14.9 | 5.3 | 4.8 | .7 | .6 | .2 |
| 1947 | 71.5 | 11.8 | 5.5 | 9.4 | 1.0 | .6 | .2 |
| 1948 | 69.8 | 9.2 | 5.7 | 13.9 | .5 | .6 | .3 |
| 1949 | 82.3 | 2.8 | 3.4 | 10.1 | .2 | .4 | .04 |
| 1950 | 76.3 | 11.0 | 7.1 | 3.9 | .2 | 1.0 | .4 |
| 1951 | 85.5 | 4.4 | 4.5 | 4.7 | .3 | .3 | .2 |
| 1952 | 91.8 | 1.9 | 3.8 | 1.5 | .4 | .4 | .2 |
| 1953 | 90.0 | 1.2 | 4.0 | 3.9 | .4 | .2 | .3 |
| 1954 | 71.3 | 7.6 | 7.6 | 11.3 | 1.4 | .5 | .4 |
| 1955 | 73.9 | 7.5 | 10.1 | 3.3 | 4.5 | .3 | .3 |
| 1956 | 81.2 | 5.8 | 8.1 | 1.0 | 3.5 | .02 | .1 |
| 1957 | 52.9 | 16.9 | 17.2 | 5.2 | 7.4 | .4 | .01 |
| 1958 | 79.6 | 10.8 | 6.5 | 1.2 | 1.9 | -- | -- |
| 1959 | 77.6 | 10.9 | 8.3 | 1.1 | 1.8 | .4 | -- |
| 1960 | 81.5 | 6.7 | 7.6 | 1.7 | 1.9 | .04 | .5 |
| 1961 | 91.0 | 3.8 | 2.4 | .2 | 2.5 | -- | -- |
| 1962 | 77.7 | 7.9 | 9.4 | 1.1 | 3.6 | -- | .2 |
| 1963 | 89.0 | 0.7 | 9.0 | -- | 1.3 | -- | -- |
| Ave. | 77.1 | 9.2 | 6.9 | 4.4 | 1.8 | 0.4 | 0.2 |

*Percent of total insured acres.

TABLE 3. Cont'd

| Year | SLOPE COUNTY | | | | | | |
|---|---|---|---|---|---|---|---|
| | Wheat | Barley | Oats | Flax | Rye | Corn | Other |
| 1942 | 74.8 | 16.5 | 3.1 | 2.4 | 2.6 | .5 | .6 |
| 1943 | 73.6 | 12.9 | 4.7 | 7.6 | .7 | .7 | .3 |
| 1944 | 78.5 | 12.0 | 6.8 | 1.7 | .3 | .3 | .4 |
| 1945 | 75.4 | 11.1 | 5.8 | 6.0 | .1 | .8 | .8 |
| 1946 | 75.8 | 11.1 | 4.7 | 5.9 | .7 | .9 | 1.0 |
| 1947 | 73.8 | 8.5 | 4.4 | 11.2 | .9 | .4 | .8 |
| 1948 | 70.3 | 6.9 | 4.4 | 17.6 | .2 | .5 | .1 |
| 1949 | 83.9 | 2.5 | 2.7 | 10.6 | .04 | .4 | .01 |
| 1950 | 78.9 | 8.4 | 5.5 | 5.8 | .3 | .9 | .2 |
| 1951 | 88.6 | 3.4 | 3.1 | 3.8 | .6 | .4 | .1 |
| 1952 | 93.2 | 1.5 | 2.8 | 1.4 | .6 | .3 | .2 |
| 1953 | 92.3 | 1.6 | 3.5 | 1.9 | .1 | .2 | .3 |
| 1954 | 70.9 | 9.4 | 6.0 | 11.0 | .2 | .3 | .4 |
| 1955 | 72.6 | 9.3 | 6.5 | 3.5 | 7.5 | .5 | .2 |
| 1956 | 77.4 | 8.5 | 5.5 | 1.9 | 5.7 | .7 | .3 |
| 1957 | 57.6 | 21.6 | 11.4 | 3.2 | 5.4 | .7 | .0 |
| 1958 | 74.4 | 16.0 | 4.7 | .6 | 3.6 | .2 | .4 |
| 1959 | 80.5 | 12.6 | 4.0 | 1.5 | 1.0 | .1 | .2 |
| 1960 | 79.2 | 11.1 | 6.5 | 1.8 | 1.2 | .0 | .2 |
| 1961 | 87.7 | 7.1 | 3.5 | .5 | 1.1 | .0 | .1 |
| 1962 | 81.6 | 9.0 | 6.3 | .5 | 2.2 | .1 | .3 |
| 1963 | 95.5 | -- | 4.5 | -- | -- | -- | -- |
| Ave. | 78.9 | 9.2 | 5.0 | 4.6 | 1.6 | 0.4 | 0.3 |

TABLE 4. AREA CHARACTERISTICS OF SELECTED TOWNSHIPS IN BOWMAN AND SLOPE COUNTIES

| | AREA 1 | | | | | AREA 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | CHIAA Data 1924-63 | % of Last 18 Years With Hail Loss (NDSID Data) | Total Acres in Twp. | % Cropland | | CHIAA Data 1924-63 | % of Last 18 Years With Hail Loss (NDSID Data) | Total Acres in Twp. | % Cropland |
| Range-Twp. | % Loss | | | | Range-Twp. | % Loss | | | |
| 131N-99W | 8.5 | 78 | 22973 | 59.8 | 129N-99W | 15.8 | 94 | 23039 | 75.6 |
| 100W | 8.3 | 89 | 22974 | 81.8 | 100W | 15.7 | 100 | 23039 | 57.1 |
| 101W | 6.0 | 78 | 22958 | 64.2 | 101W | 18.7 | 83 | 23028 | 43.2 |
| 102W | 16.8 | 72 | 22970 | 73.9 | 102W | 42. | 78 | 23050 | 26.6 |
| 103W | 14.4 | 78 | 23002 | 56.7 | 103W | 17.5 | 72 | 23040 | 27.0 |
| 104W | 20.5 | 89 | 22942 | 44.4 | 104W | 18.0 | 67 | 22024 | 15.5 |
| 132N-99W | 14.8 | 89 | 19589 | 66.6 | 130N-99W | 11.3 | 78 | 23007 | 59.4 |
| 100W | 14.7 | 78 | 19576 | 76.5 | 100W | 8.0 | 94 | 23010 | 65.5 |
| 101W | 15.1 | 83 | 19577 | 51.3 | 134N-98W | 11.4 | 94 | 23040 | 75.5 |
| 102W | 10.7 | 72 | 19604 | 65.8 | 99W | 19.1 | 94 | " | 61.7 |
| 103W | 9.3 | 83 | 19675 | 40.1 | 135N-98W | 19.8 | 89 | " | 76.1 |
| 104W | 26.2 | 83 | 19629 | 94.0 | 99W | 19.4 | 89 | " | 60.0 |
| | | | | | 100W | 13.2 | 78 | " | 53.8 |
| 133N-98W | 15.1 | 89 | 23040 | 63.7 | 101W | 11.1 | 89 | " | 27.6 |
| 99W | 16.2 | 89 | " | 90.4 | 102W | 17.1 | 94 | " | 19.8 |
| 100W | 18.9 | 83 | " | 59.8 | | | | | |
| 101W | 25.4 | 67 | " | 60.5 | 136N-98W | 4.4 | 72 | " | 81.5 |
| 102W | 10.4 | 83 | " | 39.1 | 99W | 10.7 | 89 | " | 39.3 |
| 103W | 16.4 | 89 | " | 22.7 | | | | | |
| Total Ave. | 14.9 | 81.8 | 393709 | 61.7 | | 16.2 | 85.5 | 390597 | 51.0 |

TABLE 5. HAIL LOSS DATA FOR BOWMAN AND SLOPE COUNTIES[1]

| Year | TOTAL LIABILITY INS. WRITTEN | | PERCENT OF LIABILITY WRITTEN BY: | | | | TOTAL HAIL LOSS PAID BY: | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | CHIAA | | NDSID | | CHIAA | | NDSID | |
| | Bowman Co. $ | Slope Co. $ | Bowman Co. | Slope Co. | Bowman Co. | Slope Co. | Bowman Co. | Slope Co. | Bowman Co. | Slope Co. |
| 1960 | 1,638,558 | 2,574,923 | 36 | 52 | 64 | 48 | 159,624 | 53,136 | 305,564 | 194,477 |
| 1961 | 2,716,996 | 3,201,662 | 83 | 74 | 17 | 26 | 5,297 | 1,940 | 4,187 | 13,285 |
| 1962 | 2,952,155 | 3,085,643 | 68 | 68 | 32 | 32 | 198,641 | 218,054 | 250,824 | 418,226 |
| 1963 | | | | | | | 225,784 | 303,187 | 6,500 | 1,670 |
| | | Ave. | 63 | | 37 | | | | | |

[1] Data from published statistics of the Crop-Hail Insurance Actuarial Association and the North Dakota State Insurance Department.

TABLE 6. HAIL LOSS DATA FOR NORTH EASTERN COLORADO[1]

| Twp. | Range | Total Liability Written | Total Hail Loss Allowed | Per Cent Loss |
|---|---|---|---|---|
| T2N | 44W | $ 4,075 | $ 2 | -- |
| | 45W | 2,410 | 1,799 | 75 |
| | 46W | 10,950 | 154 | 1 |
| | 47W | 85,941 | 15,940 | 19 |
| | 48W | 277,444 | 54,436 | 20 |
| | 49W | 714,796 | 129,872 | 18 |
| | 50W | 382,841 | 54,049 | 14 |
| | 51W | 270,538 | 23,743 | 9 |
| | 52W | 239,540 | 36,593 | 15 |
| | 53W | 59,842 | 4,352 | 7 |
| | 54W | 500 | 0 | 0 |
| | 55W | 9,570 | 1,702 | 18 |
| | 56W | 3,120 | 460 | 15 |
| | 57W | 2,205 | 615 | 28 |
| | 58W | 8,618 | 1,400 | 16 |
| | 59W | 32,230 | 920 | 3 |
| T3N | 44W | 790 | 0 | 0 |
| | 45W | 750 | 405 | 54 |
| | 46W | 47,979 | 6,540 | 14 |
| | 47W | 298,680 | 22,013 | 7 |
| | 48W | 296,549 | 29,713 | 10 |
| | 49W | 629,628 | 128,112 | 20 |
| | 50W | 754,210 | 169,840 | 23 |
| | 51W | 468,924 | 117,332 | 25 |
| | 52W | 182,353 | 29,804 | 16 |
| | 53W | 108,880 | 14,320 | 13 |
| | 54W | -- | -- | -- |
| | 55W | -- | -- | -- |
| | 56W | 3,244 | 75 | 2 |
| | 57W | 4,030 | 63 | 2 |
| | 58W | 4,685 | 351 | 7 |
| | 59W | 16,360 | 150 | 1 |
| T4N | 44W | 1,635 | -- | -- |
| | 45W | 2,600 | 693 | 27 |
| | 46W | 329,945 | 28,337 | 9 |
| | 47W | 536,455 | 49,358 | 9 |
| | 48W | 343,707 | 15,755 | 5 |
| | 49W | 654,110 | 30,734 | 5 |
| | 50W | 620,518 | 48,117 | 8 |
| | 51W | 332,776 | 22,899 | 7 |
| | 52W | 5,195 | 1,489 | 29 |
| | 53W | 30,025 | 6,588 | 22 |
| | 54W | -- | -- | -- |
| | 55W | 11,128 | 294 | 3 |
| T4N | 56W | $ 35,825 | $ 11,334 | 32 |
| | 57W | 34,435 | 4,817 | 14 |
| | 58W | 25,662 | 4,378 | 17 |
| | 59W | 5,680 | 1,084 | 19 |
| T5N | 44W | -- | -- | -- |
| | 45W | 36,070 | 3,244 | 9 |
| | 46W | 139,783 | 16,895 | 12 |
| | 47W | 268,440 | 45,167 | 17 |
| | 48W | 406,694 | 34,445 | 8 |
| | 49W | 372,528 | 35,665 | 10 |
| | 50W | 386,972 | 19,974 | 5 |
| | 51W | 112,893 | 7,247 | 6 |
| | 52W | 27,980 | 4,776 | 17 |
| | 53W | 5,100 | 2,540 | 50 |
| | 54W | 9,626 | 144 | 2 |
| | 55W | 2,451 | -- | -- |
| | 56W | 42,052 | 3,814 | 9 |
| | 57W | 23,310 | 3,635 | 16 |
| | 58W | 48,470 | 14,045 | 29 |
| | 59W | -- | -- | -- |
| T6N | 44W | 68,242 | 8,612 | 13 |
| | 45W | 106,311 | 19,057 | 18 |
| | 46W | 325,838 | 29,645 | 9 |
| | 47W | 390,986 | 54,835 | 14 |
| | 48W | 493,982 | 85,340 | 17 |
| | 49W | 615,984 | 70,251 | 11 |
| | 50W | 182,150 | 13,083 | 7 |
| | 51W | 135,008 | 10,620 | 8 |
| | 52W | 5,829 | 1,222 | 8 |
| | 53W | 10,868 | 913 | 21 |
| | 54W | 131,398 | 10,614 | 8 |
| | 55W | 57,497 | 14,332 | 25 |
| | 56W | 137,883 | 18,509 | 13 |
| | 57W | 36,552 | 2,162 | 6 |
| | 58W | 73,034 | 7,374 | 10 |
| | 59W | 2,000 | -- | -- |
| T7N | 44W | 173,557 | 24,754 | 14 |
| | 45W | 452,231 | 83,673 | 18 |
| | 46W | 226,673 | 32,081 | 14 |
| | 47W | 400,071 | 28,798 | 7 |
| | 48W | 516,648 | 46,600 | 9 |
| | 49W | 475,349 | 64,038 | 13 |
| | 50W | 446,680 | 46,761 | 10 |

[1] Data from Crop-Hail Insurance Statistics - direct writings 1931 through 1962. Published by Crop-Hail Insurance Actuarial Association.

TABLE 6. HAIL LOSS DATA FOR NORTH EASTERN COLORADO--Cont'd

| Twp. | Range | Total Liability Written | Total Hail Loss Allowed | Per Cent Loss |
|---|---|---|---|---|
| T7N | 51W | $191,679 | $ 24,200 | 13 |
| | 52W | 2,645 | 35 | 1 |
| | 53W | 73,441 | 9,807 | 13 |
| | 54W | 194,225 | 27,208 | 14 |
| | 55W | 295,748 | 57,957 | 20 |
| | 56W | 409,367 | 102,187 | 25 |
| | 57W | 230,965 | 20,826 | 9 |
| | 58W | 292,357 | 18,390 | 6 |
| | 59W | 100,262 | 9,851 | 10 |
| T8N | 44W | 430,779 | 25,901 | 6 |
| | 45W | 401,213 | 46,840 | 12 |
| | 46W | 487,946 | 57,963 | 12 |
| | 47W | 342,435 | 28,831 | 8 |
| | 48W | 563,615 | 79,115 | 14 |
| | 49W | 711,341 | 95,466 | 13 |
| | 50W | 438,689 | 40,232 | 9 |
| | 51W | -- | -- | -- |
| | 52W | 47,602 | 4,731 | 10 |
| | 53W | 122,975 | 11,495 | 9 |
| | 54W | 102,778 | 16,864 | 16 |
| | 55W | 10,489 | 1,017 | 10 |
| | 56W | 134,752 | 19,635 | 15 |
| | 57W | 97,923 | 7,818 | 8 |
| | 58W | 28,185 | 184 | 1 |
| | 59W | 8,910 | 2,100 | 24 |
| T9N | 44W | 555,819 | 36,819 | 6 |
| | 45W | 408,578 | 20,528 | 13 |
| | 46W | 247,903 | 151,080 | 11 |
| | 47W | 378,884 | 30,092 | 14 |
| | 48W | 97,963 | 18,740 | 19 |
| | 49W | 72,685 | 12,844 | 18 |
| | 50W | 1,490 | -- | -- |
| | 51W | 26,345 | 3,035 | 11 |
| | 52W | 50,342 | 4,754 | 9 |
| | 53W | 175,191 | 15,625 | 9 |
| | 54W | 178,153 | 8,823 | 5 |
| | 55W | 184,832 | 10,604 | 8 |
| | 56W | 10,957 | 450 | 4 |
| | 57W | 17,862 | 1,067 | 6 |
| | 58W | 12,000 | 2,470 | 21 |
| | 59W | 600 | -- | -- |
| T10N | 44W | $1,261,138 | $153,413 | 12 |
| | 45W | 846,830 | 75,211 | 9 |
| | 46W | 794,659 | 74,613 | 9 |
| | 47W | 118,574 | 5,990 | 5 |
| | 48W | 27,200 | -- | -- |
| | 49W | 13,864 | 178 | 1 |
| | 50W | 154,441 | 19,787 | 13 |
| | 51W | 82,757 | 17,274 | 21 |
| | 52W | 102,651 | 19,990 | 20 |
| | 53W | 55,185 | 7,110 | 13 |
| | 54W | 7,765 | 132 | 2 |
| | 55W | 26,837 | 1,778 | 7 |
| | 56W | 800 | -- | -- |
| | 57W | -- | -- | -- |
| | 58W | -- | -- | -- |
| | 59W | -- | -- | -- |
| T11N | 44W | 219,514 | 20,996 | 10 |
| | 45W | 183,016 | 21,695 | 12 |
| | 46W | 40,723 | 4,592 | 11 |
| | 47W | 94,831 | 8,073 | 9 |
| | 48W | 95,242 | 11,286 | 12 |
| | 49W | 85,072 | 11,969 | 14 |
| | 50W | 64,680 | 2,721 | 4 |
| | 51W | 151,048 | 7,728 | 5 |
| | 52W | 120,956 | 11,140 | 9 |
| | 53W | 156,101 | 23,783 | 15 |
| | 54W | 3,477 | -- | -- |
| | 55W | 4,050 | -- | -- |
| | 56W | 5,475 | -- | -- |
| | 57W | 6,550 | 50 | 76 |
| | 58W | 23,615 | 2,366 | 10 |
| | 59W | 82,683 | 12,128 | 15 |
| Totals for Area | | 28,208,477 | 3,716,301 | 1957 |
| | | | Ave. | 13.9% |

TABLE 7. SEEDING DATA[1]

| | Date | Hours Seeding | Remarks |
|---|---|---|---|
| | 6-5-61 | 1:15 | |
| | 6-11-61 | 1:00 | |
| | 7-8-61 | 2:00 | Rain--few small hail SE area--severe hail 15 miles south of N.D. Border |
| 1961--8:15 | | | Seeded small cumulus build up in Buffalo Springs area - 1" rain |
| | 7-9-61 | 1:15 | Seeding on small scattered cu scattered short showers - ave. .20" |
| | | 2:00 | Seeded advancing storm with squall line 30 mi. wide, cloud base 9500' msl - severe hail SW of area - severe turb. 6000' msl |
| Est. | 7-10-61 | 0:45 | Seeded storm moving NE through area - apparently "dry" cloud - changed to N. |
| 1962--15:00 | 7-18-62 | 2:30 | |
| | 6-1-63 | 2:00 | Large cu overhead and to east - 60" first - .50" second storms |
| | 6-3-63 | | Cloudy--light rain |
| | 6-4-63 | G.G.[2] Operating | Thunderheads - storm - 60" rain - no hail |
| | 6-5-63 | G.G. Operating | 60" rain - no hail |
| | 6-6-63 | G.G. Operating | Small build up |
| | 6-7-63 | G.G. Operating | Light cu |
| | 6-8-63 | 2:20 | Few pea size hail - heavy hall south of Rhame - some 100% loss |
| 1963--35:00 | | | Seeded Reeder - Planes and ground generators used 1.40 - 2" rain |
| 14 Ground Gen. = 192 hrs. | 6-14-63 | G.G. Operating | Both planes and ground generator used - .40" rain |
| 7 G.G. ? hrs. | 6-17-63 | G.G. Operating | Plane and ground generator operating - .30" rain--no hail |
| | 6-18-63 | G.G. Operating | Trace |
| | 6-19-63 | ----- | Sprinkle |
| | 6-20-63 | :30 | Large buildup 7 P.M. - .40 rain - ground and plane gen. |
| | 6-21-63 | 3:30 | .70 rain - no hail |
| | 6-22-63 | Operating | Large thunderheads to SE |
| | 6-24-63 | :30 | .80" rain - no hail - few large Hettinger |
| | 6-29-63 | G.G. Operated | Light thunder activity |

1 Date from flight logs of Wilbur Brewer and Bill Fisher.
2 G.G. stands for ground generators.

TABLE 7. SEEDING DATA--Cont'd

| Date | Hours Seeding | Remarks |
|---|---|---|
| 7-5-63 | 1:45 | Both planes seeding - .30" rain |
| 7-6-63 | G.G. Operated | Sprinkle - large buildup WNW |
| 7-10-63 | 2:00 | Both planes seeding - storm passed - no rain or hail |
| 7-18-63 | 2:00 | Threatening later afternoon - no rain or hail |
| 7-23-63 | | Large thunderheads east |
| 7-9-63 | -- | Pea sized hail |
| 7-31-63 | -- | Hail at Ives --> SE - wind - 20" rain no hail |
| 8-5-63 | 1:45 | Both planes seeding |
| 8-8-63 | 1:30 | 1 plane seeding - 30" rain - hail SW corner of Bowman County |
| 8-10-63 | 2:00 | 1 plane seeding |
| 8-11-63 | -- | Heavy buildup - E, SE and NE |
| 8-21-63 | 1:00 air<br>4:00 ground | Rain violent clouds to SE |
| 8-25-63 | -- | Large thunderheads ENE |
| 8-27-63 | 1:25 | 1 plane seeding |

TABLE 8. SUMMARY OF STORMS

| Storm of Date | Hour | Total No. of Claims | Total No. of Acres Damaged | Per Cent Loss Per Twp. | Primary Area of Storm | Storm of Date | Hour | Total No. of Claims | Total No. of Acres Damaged | Per Cent Loss Per Twp. | Primary Area of Storm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year: 1960 | | | | | | | | | | | |
| May 31 | 0400 | 1 | 4 | 0.1 | T[1] | July 23 | 2000 | 1 | 7 | 2.9 | T |
| June 12 | 1600 | 1 | 42 | 0.7 | C | Aug. 4 | 0900 | 4 | 19 | 0.1 | T,C |
| June 20 | 2000 | 15 | 55 | 12.4 | C | Aug. 4 | 1700 | 15 | 852 | 13.8 | T,C |
| June 27 | 1900 | 1 | 15 | 0.2 | C | Aug. 4 | 2200 | 83 | 1165 | 3.7 | T,C |
| July 1 | 2100 | 294 | 9768 | 35.0 | T | Aug. 5 | 0900 | 6 | 47 | 4.6 | T,C |
| July 2 | 2100 | 1 | 50 | 13.6 | T | Aug. 5 | 1700 | 238 | 4060 | 12.5 | T,C |
| July 11 | 1700 | 2 | 7 | 0.80 | T,C | Aug. 5 | 2200 | 53 | 686 | 3.2 | T,C |
| July 12 | 0300 | 1 | 7 | 0.1 | T | Aug. 6 | 0000 | 1 | 2 | 0.1 | T |
| July 12 | 1600 | 62 | 1271 | 6.6 | T,C | Aug. 9 | 1400 | 5 | 94 | 4.8 | T |
| July 13 | 1600 | 32 | 566 | 3.6 | C | Aug. 10 | 1700 | 1 | 16 | 0.2 | T |
| July 15 | 1700 | 1 | 7 | 2.9 | T | Aug. 13 | 1800 | 18 | 140 | 2.2 | T,C |
| July 19 | 2300 | 2 | 12 | 0.5 | C | Jan. 41'62 | -- | 1 | 25 | 0.5 | C |
| | | | | | | Mar. 4'62 | 2100 | 1 | 9 | 0.2 | C |
| Total Number of Storms: 25<br>Day: 15<br>Night: 10 | | | | | | | | | | | |
| Year: 1961 | | | | | | | | | | | |
| June 11 | 1800 | 15 | 180 | 2.5 | T | July 29 | 2300 | 2 | 5 | 0.3 | C |
| July 8 | 1900 | 6 | 35 | 1.0 | T,C | July 30 | 2300 | 17 | 261 | 2.5 | T,C |
| July 20 | 2200 | 3 | 55 | 0.6 | C | Aug. 31 | 1200 | 5 | 38 | 0.7 | C |
| Total Number of Storms: 6<br>Day: 3<br>Night: 3 | | | | | | | | | | | |

1. T = Target area
C = Control area

TABLE 8. SUMMARY OF STORMS--Cont'd

| Storm of Date | Hour | | | | | Storm of Date | Hour | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year: 1962 | | | | | | | | | | | |
| June 2 | 0000 | 6 | 182 | 4.9 | C | July 18 | 2100 | 9 | 28 | 0.8 | T |
| June 7 | 1500 | 7 | 99 | 7.1 | T | July 19 | 2130 | 12 | 208 | 5.2 | T |
| June 20 | 2000 | 9 | 35 | 0.3 | T | July 27 | 1300 | 1 | 2 | 0.1 | C |
| June 22 | 2130 | 46 | 815 | 31.9 | C | Aug. 3 | 1800 | 13 | 62 | 1.0 | T |
| July 2 | 0950 | 14 | 333 | 18.9 | C | Aug. 6 | 1500 | 27 | 362 | 5.3 | T |
| July 2 | 1950 | 242 | 4395 | 12.8 | C | Aug. 8 | 1700 | 111 | 998 | 4.5 | T,C |
| July 3 | 2100 | 1 | 2 | 0.2 | T | Aug. 9 | 1650 | 5 | 88 | 4.0 | T |
| July 6 | 1950 | 531 | 14332 | 26.1 | T,C | Aug. 10 | 1200 | 5 | 56 | 0.6 | T |
| July 7 | 2200 | 2 | 33 | 0.7 | T | Aug. 22 | 1750 | 30 | 265 | 1.0 | T |
| July 9 | 2300 | 13 | 462 | 2.8 | T,C | Aug. 27 | 1500 | 4 | 14 | 0.4 | T |
| July 10 | 2200 | 3 | 203 | 2.5 | T | Unk. | 0000 | 36 | 1015 | 8.5 | T |
| Total Number of Storms: 22 | | | | | | | | | | | |
| Day: 14 | | | | | | | | | | | |
| Night: 8 | | | | | | | | | | | |
| Year: 1963 | | | | | | | | | | | |
| May 24 | 0000 | 9 | 146 | 4.4 | C | July 17 | 1200 | 4 | 6 | 0.1 | C |
| June 1 | 1500 | 2 | 10 | 1.3 | T | July 18 | 0450 | 430 | 8606 | 16.1 | C |
| June 8 | 0500 | 5 | 109 | 1.6 | T | July 18 | 1500 | 3 | 554 | 1.3 | C |
| June 8 | 1930 | 365 | 5711 | 16.5 | T,C | July 24 | 0300 | 24 | 61 | 3.9 | C |
| June 18 | 1700 | 3 | 26 | 1.5 | T | July 26 | 0300 | 1 | 3 | 0.1 | T |
| June 20 | 1700 | 11 | 76 | 1.3 | T | July 30 | 2130 | 507 | 9534 | 18.8 | T,C |
| June 21 | 2000 | 3 | 10 | 0.2 | C | July 31 | 2000 | 11 | 140 | 1.2 | T,C |
| June 22 | 1800 | 7 | 69 | 1.1 | T | Aug. 1 | 2100 | 7 | 112 | 0.5 | T,C |
| June 23 | 0000 | 8 | 80 | 1.2 | C | Aug. 7 | 1400 | 2 | 43 | 0.6 | T |
| June 24 | 2200 | 84 | 530 | 1.5 | T,C | Aug. 8 | 0700 | 22 | 327 | 1.5 | T,C |
| June 25 | 2130 | 7 | 78 | 1.6 | T | Aug. 8 | 2100 | 647 | 10435 | 11.0 | T,C |
| June 28 | 2000 | 2 | 31 | 0.5 | C | Aug. 9 | 2230 | 16 | 340 | 2.8 | T,C |
| July 1 | 1900 | 2 | 51 | 1.2 | T | Aug. 10 | 1900 | 2 | 12 | 7.3 | C |
| July 2 | 0000 | 4 | 37 | 0.4 | C | Aug. 11 | 2100 | 27 | 589 | 56.0 | C |
| July 6 | 0600 | 114 | 1414 | 2.3 | C | Aug. 15 | 2100 | 2 | 180 | 5.5 | C |
| July 8 | 2100 | 1 | 7 | 0.1 | T | Aug. 21 | 1900 | 5 | 124 | 73.3 | C |
| July 9 | 2200 | 1 | 18 | 0.2 | T | Aug. ? | 2100 | 1 | 30 | 0.7 | T |
| July 10 | 2200 | 3 | 16 | 11.2 | C | Sept. 10 | Unk | 2 | 49 | 4.9 | T |
| Total Number of Storms: 36 | | | | | | | | | | | |
| Day: 18 | | | | | | | | | | | |
| Night: 18 | | | | | | | | | | | |

# FLIGHT LOG

## FLIGHT INFORMATION

Pilot Sand - W Date July 6, 1964 Aircraft No. 682

Time of T O 1645 Airport FCL

Time of Landing 1845 Airport FCL

Total Flt time 2 + 00

## SEEDING DATA

| | Right Burner | | | Left Burner | | |
|---|---|---|---|---|---|---|
| Time On | 1700 | 1800 | | | INOP. | |
| Time Off | 1750 | 1832 | | | | |
| Time in Use | 50 | 32 | | | | |
| Total Time | 1 + 22 | | | | | |

Amt. of seeding soln. used 3.4 gal. Strength of soln. 5 %

Alt. of seeding 13,500 MSL. Free air temp at seed level -8 °F

## WEATHER DATA

Alt. of cloud base 10,500 MSL. Freezing level 11,000 MSL.

Ground level wind direction and speed: N.W. at 6 miles per hour

Intensity of updrafts: Most common 400 ft/min

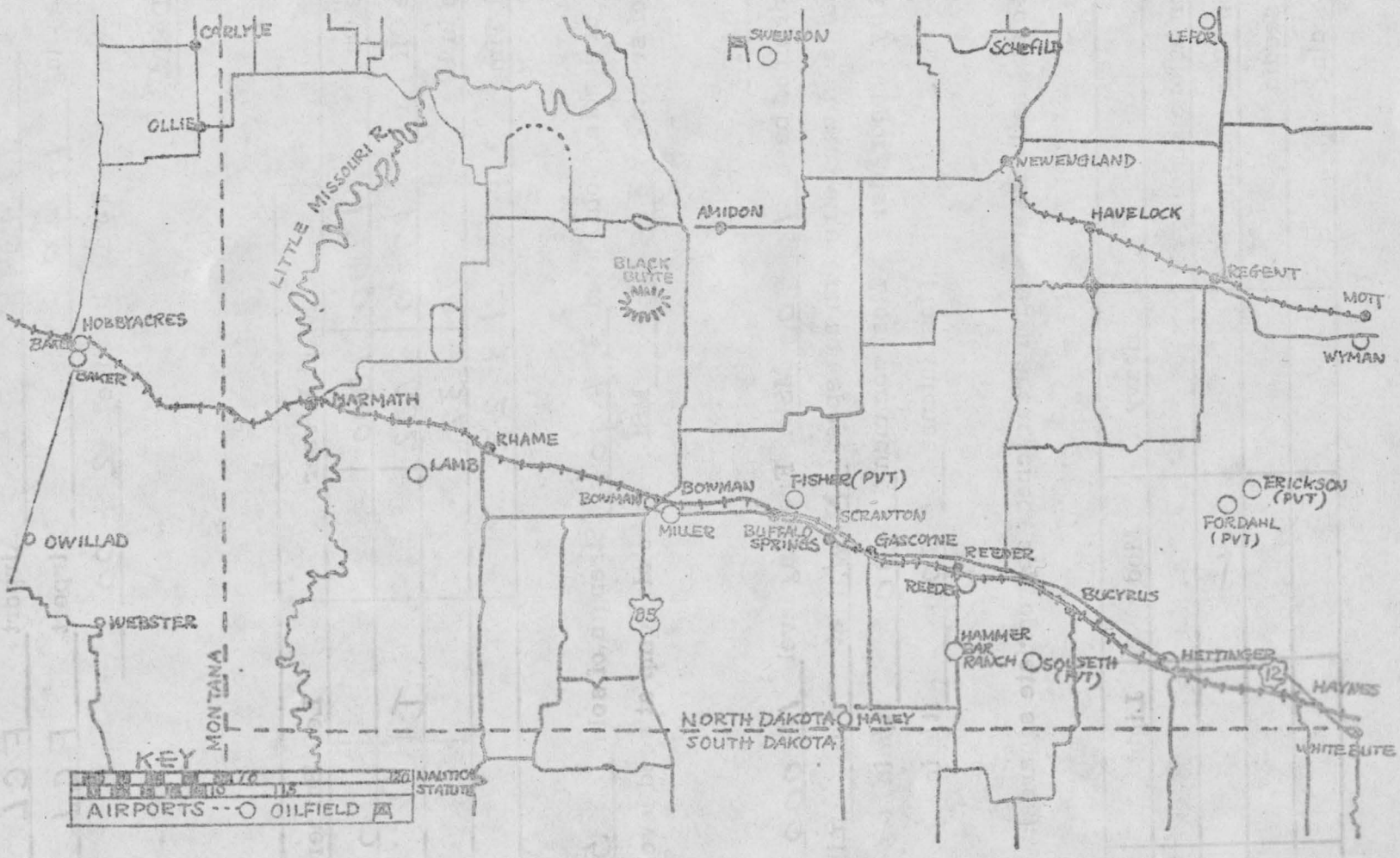
Most intense 5000 ft/min

Precipitation and hail data in seeded area: (check appropriate squares)

| | Heavy | Mod. | Light | None |
|---|---|---|---|---|
| Precipitation before seeding | | | | ✓ |
| Precipitation after seeding | | ✓ | | |
| Hail before seeding | | | | ✓ |
| Hail after seeding | | | | ✓ |

FLIGHT DATA

Please indicate flight path, time and location of burner operations, areas of thunderstorms, hail and/or rain, direction of storm movement, and the location of updrafts.




ADDITIONAL COMMENTS:

Heavy thunderstorm activity - Aircraft sucked into cloud - sent to 50,000 ft where it fell out in an uncontrollable state

# APPENDIX B

Figures

Data from N.D. State Ag Service and J.D. Latham, County Agent

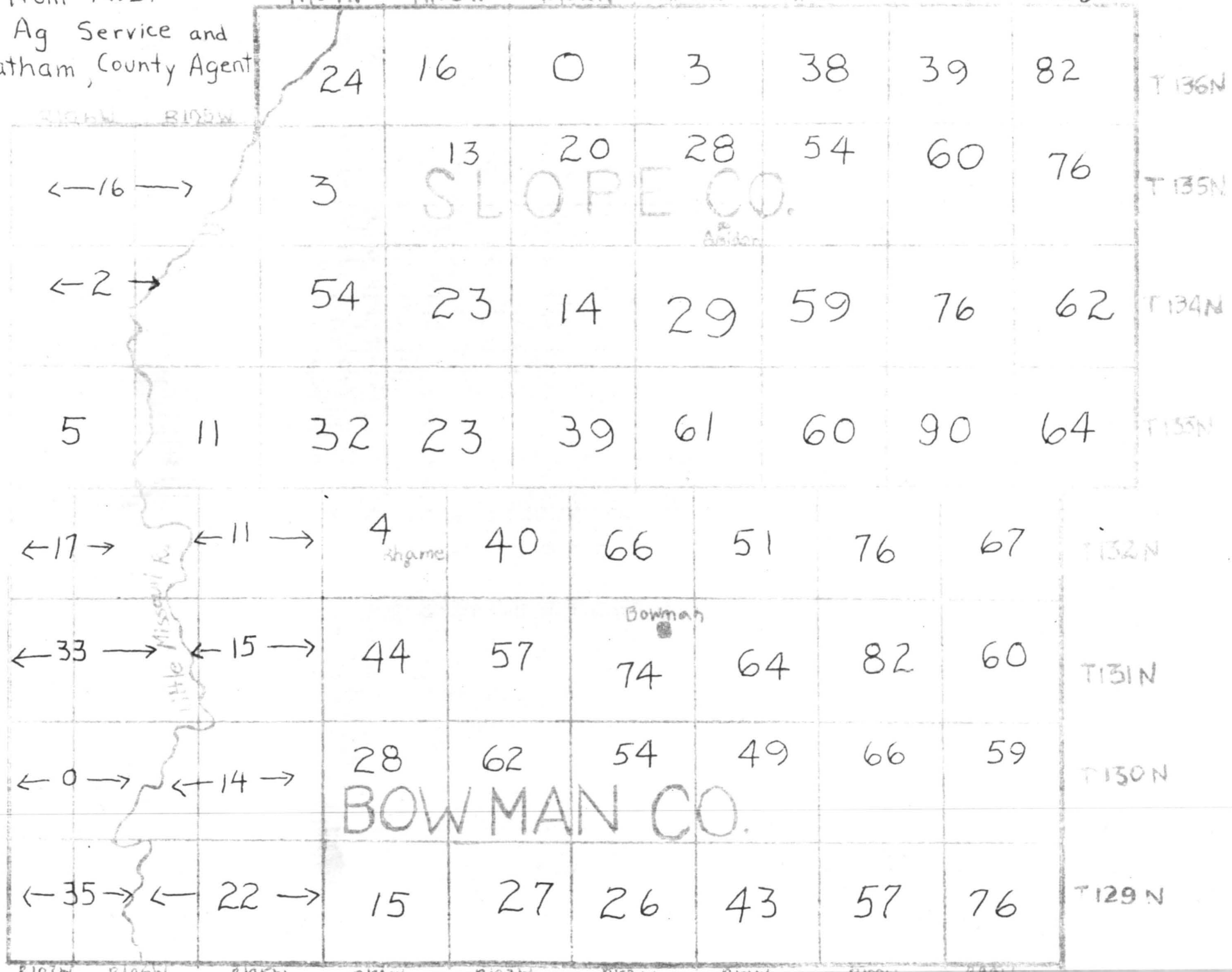
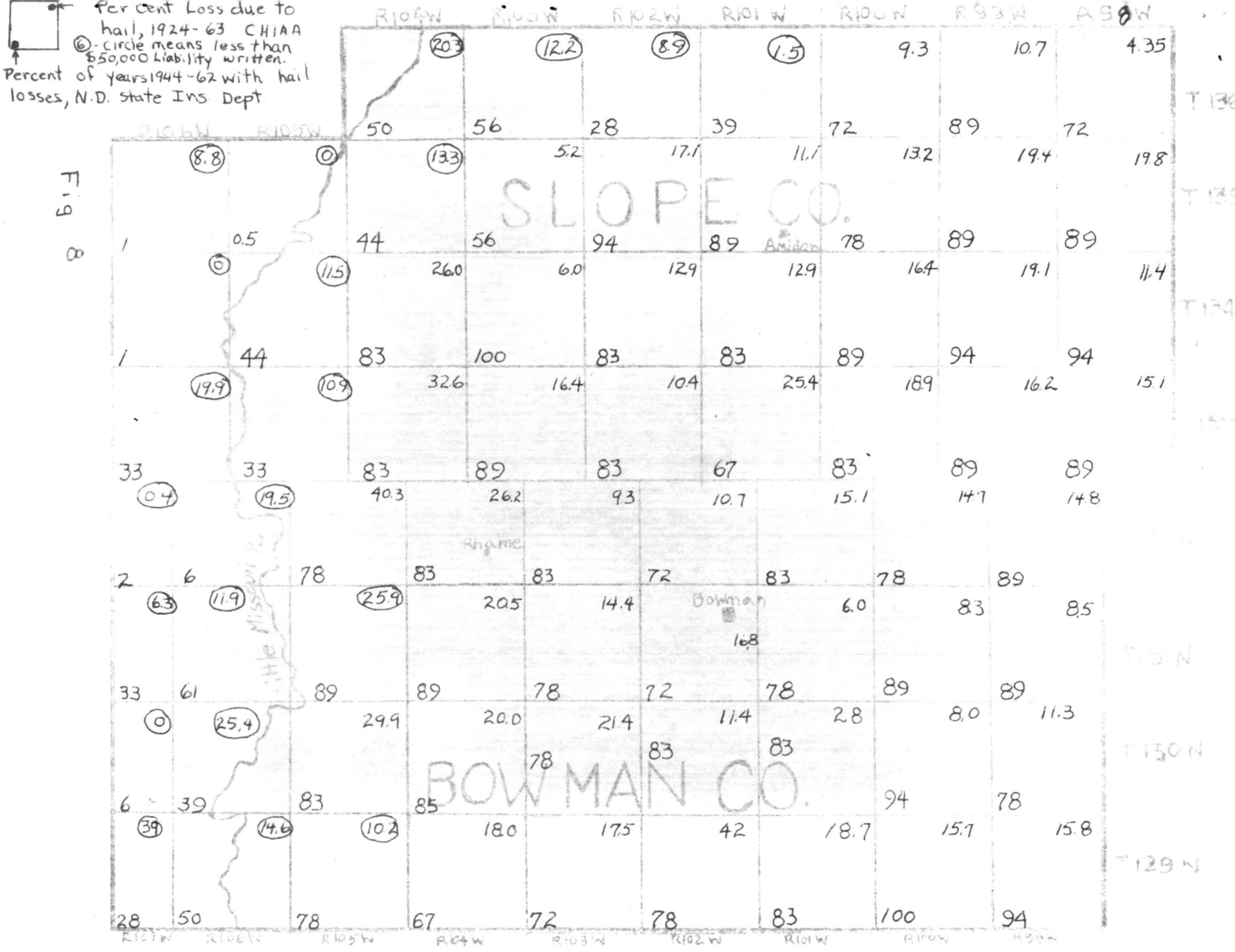



FIG 7 Percent Cropland in Bowman and Slope Co.

Ave cropland Bowman 42.7%
Slope 39%


Percent Loss due to hail, 1924-63 CHIAA
⑥-circle means less than $50,000 Liability written.
Percent of years 1944-62 with hail losses, N.D. State Ins Dept
R104W R103W R102W R101W R100W R99W R98W
T136N
T135N
T134N
T133N
T132N
T131N
T130N
T129N
SLOPE CO.
BOWMAN CO.
Amidon
Bowman
Rhame
White Butte
20.3 12.2 8.9 1.5 9.3 10.7 4.35
50 56 28 39 72 89 72
8.8 0 13.3 5.2 17.1 11.1 13.2 19.4 19.8
1 0.5 44 56 94 89 78 89 89
0 11.5 26.0 6.0 12.9 12.9 16.4 19.1 11.4
1 44 83 100 83 83 89 94 94
19.9 10.9 32.6 16.4 10.4 25.4 18.9 16.2 15.1
33 33 83 89 83 67 83 89 89
0.4 19.5 40.3 26.2 9.3 10.7 15.1 14.7 14.8
2 6 78 83 83 72 83 78 89
6.3 11.9 25.9 20.5 14.4 6.0 8.3 8.5
16.8
33 61 89 89 78 72 78 89 89
0 25.4 29.9 20.0 21.4 11.4 2.8 8.0 11.3
78 83 83
6 39 83 85 94 78
39 14.6 10.2 18.0 17.5 42 18.7 15.7 15.8
28 50 78 67 72 78 83 100 94
R107W R106W R105W R104W R103W R102W R101W R100W R99W

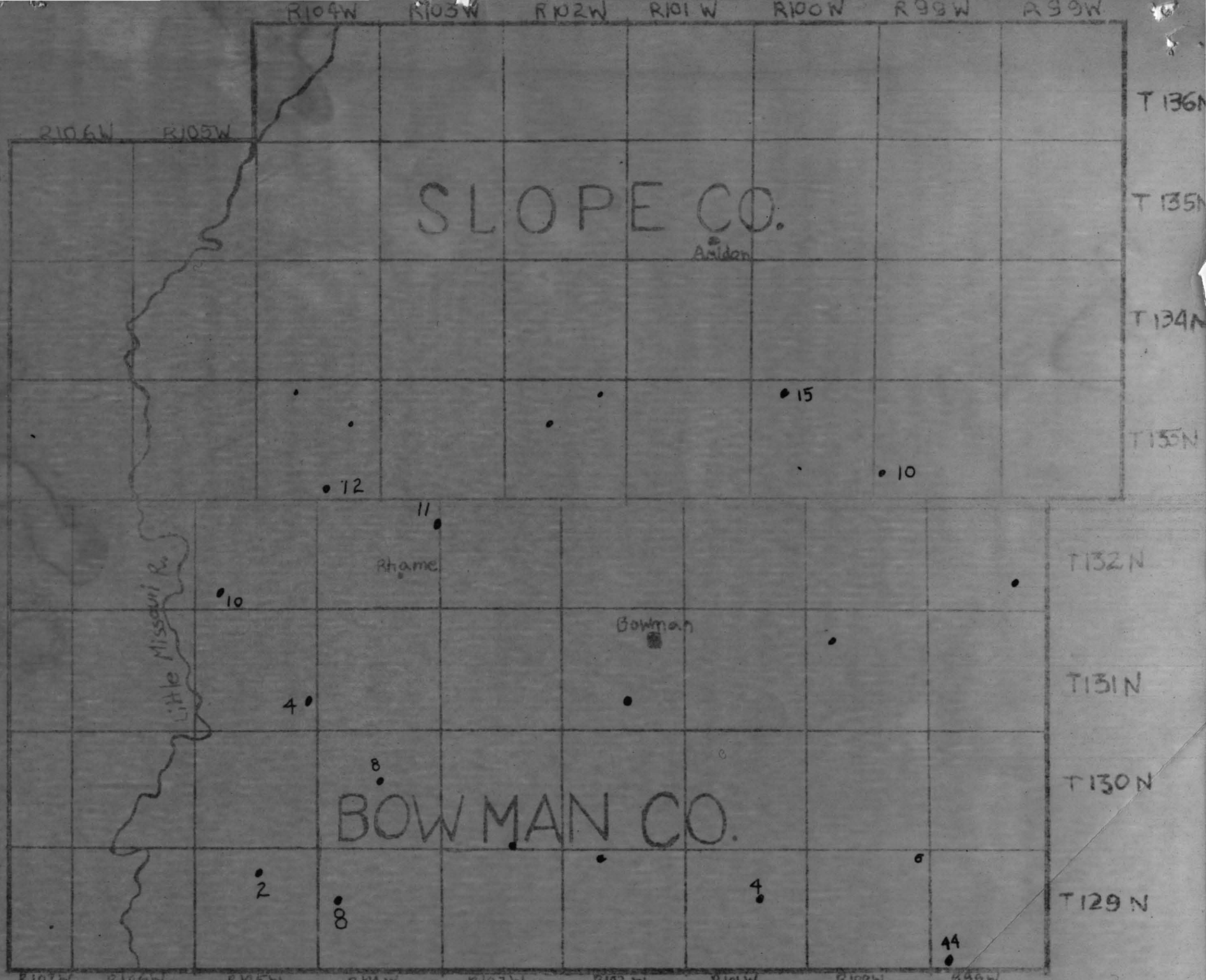



Figure 9 Location of Ground Generators - 1963