THE ALBERTA HAIL PROJECT: UPDATE 1975

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INTRODUCTION

Hail causes $40 to $50 million, and sometimes twice that amount in crop losses each year in Alberta and up to $1 billion loss around the world. The Alberta Government established the Interim Weather Modification Board and the Alberta Hail Project in 1973 to hasten the development of hail suppression technology and test it on a wide scale in Alberta. The new Project is an extensive five year hail suppression test incorporating the former Alberta Hail Studies (ALHAS) research program.

The Interim Weather Modification Board (IWMB) was formed in response to the report of the Special Legislative Committee on Crop Insurance and Weather Modification to the Legislative Assembly of Alberta (1973). The IWMB was established under Alberta Agriculture with a mandate to administer hail suppression and hail research programs with continuing evaluation. All Provincial Government funds for weather modification activities are now directed through the IWMB except for some permanent staff support at Alberta Research Council.

The IWMB has assumed the operational responsibilities of the former ALHAS project and incorporated them into a program designed to determine the practical and economical feasibility of hail suppression with current technology. The program combines as much cloud seeding as possible at the request of agriculture groups, with a large research component to help answer some of the questions about hailstorm and hailstone formation processes and also to increase the accuracy of the evaluation of the seeding. An area of 18,500 square miles (Fig. 1), centered on the radar site at the Red Deer Industrial Airport, has been designated for the project.

Cloud seeding is conducted by seven aircraft either from cloud top, utilizing dropable pyrotechnic flares, or from cloud base with pyrotechnic flares mounted on the wings of the aircraft. The cloud seeding is conducted from June 20 to September 10 of each year.

Radar data from storms will be combined with hailfall data and crop damage information for seeded and unseeded storms in attempts to assess the seeding effectiveness.

HYPOTHESIS:

The hypothesis assumed for the Alberta experiment is the "competing embryo" concept. Briefly, this concept is that the introduction of sufficient artificial ice nuclei into the updraft of hail producing clouds leads to the formation of more hail embryos that will compete for the liquid water in the storm and redistribute its distribution to more but smaller hailstones.

This hypothesis makes the following important assumptions:

1. Natural hailstorms are deficient in ice nuclei active at warm temperatures.

2. The storm efficiency will not increase.

3. The air or moisture flux into the storm will not increase.

A second and less important concept is that the increased ice nuclei will promote the freezing of a larger amount of the cloud water at warmer temperatures and reduce the supply of growth medium for the hailstones.

The cloud seeding experiment will look for changes in the hailstone size distribution, hailfall energy, hailfall mass, hailfall area and damage to crops.

EXPERIMENTAL DESIGN:

There are two aspects to the experiment's goal stated above. They are 1) by how much can hail be suppressed and 2) is this amount economical. The latter aspect may be interpreted as to defining in what areas of the Province would such an operation be economical.

The area designated for the test is shown in Figure 1. A full seed operation is conducted in the southern half of the area with all storms with reflectivities greater than 35 dBZ seeded.

In the northern region a seed/no-seed decision is made on a 50/50 randomized basis once for each experimental day. During 1974, an experimental day was declared at the first appearance of a 45 dBZ radar echo within the area. All storms with reflectivities above 35 dBZ were then seeded for the remainder of the day.

Midway through the 1974 season, the IWMB, in efforts to further increase the "protection" of the southern area, required that all southward moving storms expected to enter the southern area be seeded regardless of the seed/no-seed decision.

A further change was made in the seeding criteria prior to the 1975 season to initiate seeding of storms earlier in their lifetimes. This change was a reduction in the experimental day declaration from the first appearance of a 45 dBZ radar echo to the first appearance of a 35 dBZ radar echo. This change has resulted in more declared experimental days than would otherwise have been, but has also resulted in several declared days with no hail reported.

Also, a 12 mile wide "decision zone" (township 37 and 38, Fig. 1) was also established between the two areas. In this zone all storms are seeded unless they display a northward component of motion when they may be treated as in the northern area.

These decisions obviously effect the number of hail days available for statistical analysis and the randomness of the original design.

SEEDING TECHNIQUES:

The seeding techniques used for the experiment are illustrated in Figure 2. The cloud top seeding method was first developed by Simpson et. al. (1970) in Florida and adapted to Alberta hailstorms by Summers et al. (1972). The technique is closely tied to the Alberta multi-cell storm concept as described by Chisholm and Renick (1972).

Five aircraft (turbocharged light twin engined) are equipped to carry 104 50-gram pyrotechnic flares. Five to ten flares are released per seeding run from an altitude where the ambient temperature is -14C. The flares burn one minute while falling 6000 feet to near the -5C level inside the developing cloud towers.

Cloud base seeding is conducted by seven aircraft (including the five top-seeding aircraft) carrying 32 70-gram seven-minute burn pyrotechnic flares attached to wing racks. One to five flares are ignited simultaneously as the aircraft flies in the storm updraft area.

The meteorological conditions associated with each storm dictate which seeding technique is used -- sometimes both together.

EVALUATION:

Executing the cloud seeding experiment is a relatively straightforward procedure -- evaluating the effects is not. The diverse nature of storms, both physically and geographically, combined with our "limited" understanding of them, and relatively poor measuring capabilities, makes evaluation a most difficult task though a most important one. Many past programs have terminated because of the lack of adequate measurements upon which to base an acceptable analysis.

The analysis procedures for the Alberta program are now being worked out (Goyer, 1975a and Wong, 1975). However, an extensive effort is being made to measure storm parameters as accurately as possible with radar and precipitation fallout, with hail reports and precipitation amounts, samples for silver analysis, hailpads for determining hailfall energies and size distributions, crop damaage insurance data and meteorological data.

The evaluation is expected to follow a physical-statistical approach. A. Feuerverger* suggested a multiple linear regression model be used for the analysis. This model would contain a dummy variable as a seeding parameter and as many independent suitable meteorological or otherwise "predictor" variables as could be found. The dependent variables would

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be the various related hailfall and radar measurements. This model, though, stresses the need for randomization.

In a recent analysis, Goyer (1975b) studied radar echo tops from 23 seeded and 23 non-seeded storms. He defines a growth factor (T_1/T_o) where T_o is the echo top above 7.6 Km. height integrated over the twenty minute period prior to first seeding and T_1 is the integrated echo top above 7.6 Km. from twenty minutes prior to first seeding until the echo top descends below 7.6 Km. The growth factors for the seeded storms are smaller than for the non-seeded storms with the difference significant at the 2.5% level (Mann-Whitney test). A physical explanation for the difference is difficult. The results also show that the average growth factor decreases as the average seeding rate increases.

Recent analyses at McGill University by R. Rogers* and others show large decreases in the area covered by higher intensity echoes shortly after the onset of seeding. Only a limited number of storm analyses have been completed to date and not all have shown the same result.

On 6 July 1975, a large severe storm passed southeastward through the target area. This storm travelled a distance of over 250 miles in eight hours with hail up to 3.5 inches in diameter. This storm was seeded with 104 flares over a forty minute period. Coincident with the seeding are decreases in the storm top, hailswath width and maximum hail size. These apparent changes are particularly interesting, however, they are not generally or consistently observed. The hailstorm on 5 August 1975 has no such features in the hailswath coincident with the seeding.

Many interesting, some encouraging and some discouraging, events are happening in the seeding experiments but no consistent pattern has yet been detected. Only through discovering the reasons for, or not for, these events can we progress, as so far, the results are quite conflicting.

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*Private communication

FIGURE 1

- TARGET AREA -

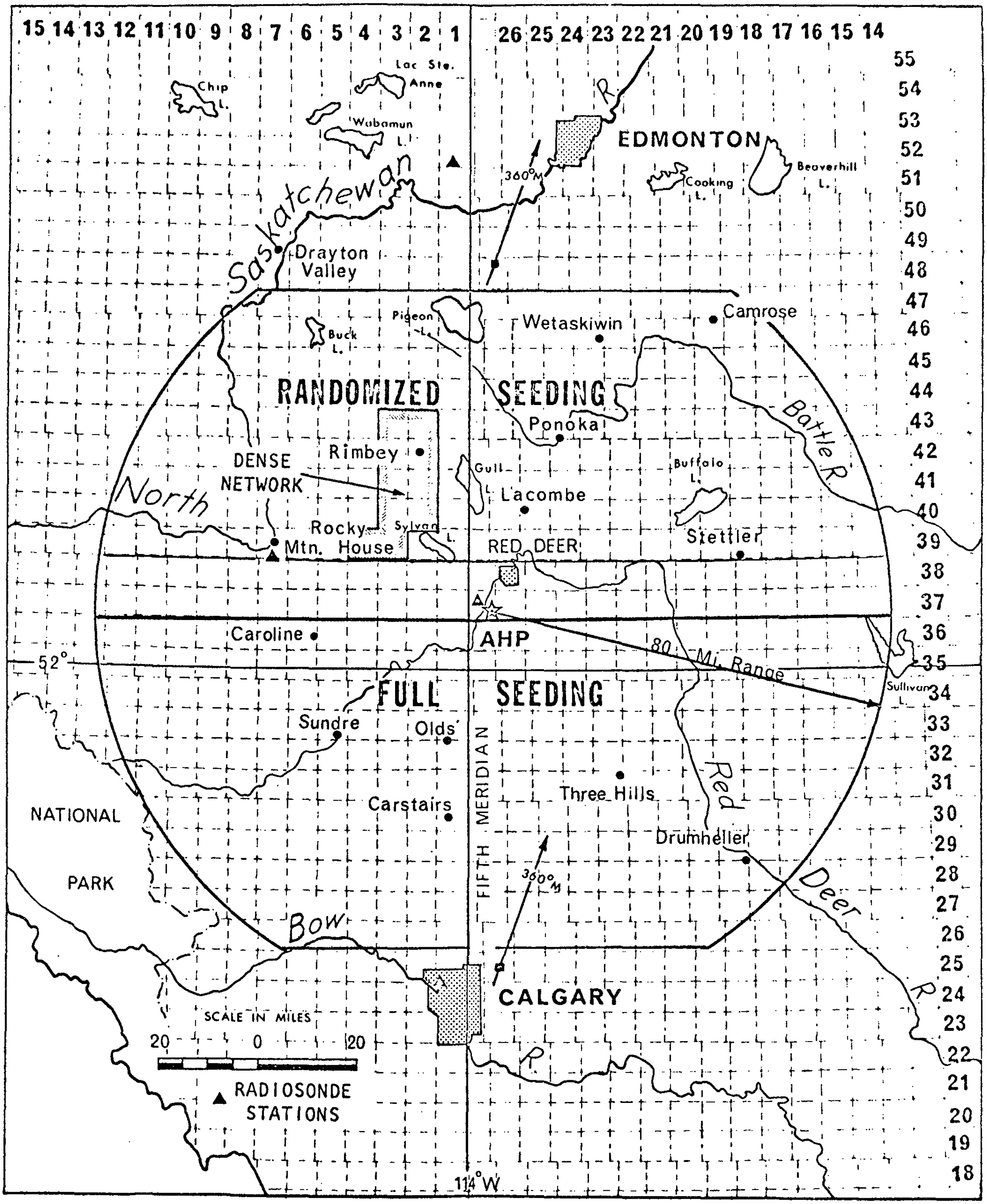

FIGURE 2

- CLOUD SEEDING LOGISITCS -