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CONTROLLED ACCUMULATION OF BLOWING SNOW

by

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COLORADO WATER RESOURCES RESEARCH INSTITUTE

Colorado State University
Fort Collins, Colorado

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CONTROLLED ACCUMULATION OF BLOWING SNOW

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OWRR Project A-004-Colo

Title: Atmospheric Water

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ABSTRACT

CONTROLLED ACCUMULATION OF BLOWING SNOW

An experiment designed to trap falling snow and controll drifting snow over the high alpine regions of the Colorado Rocky Mountains is described. The experiment is based on the fact that a wind shift occurs following many snow occurrences over this region and a snow fence system was developed to act both as a trap for falling snow and as a channelling mechanism to control drifting snow. The report describes various fence designs that were tested and provides photographic evidence of the fence system's influence on the blowing snow. The system was effective in increasing the volume of snow in the target region but the density of snow in the controlled drift was found to be only eighty percent of the density in adjacent natural drift.

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Acknowledgement

Project A-004-Colo, titled "Atmospheric Water" was initially proposed as an atmospheric water budget study, but available budget dictated a delimitation in objective. Controlled accumulation of snowfall on high altitude sites was selected as the component of the water budget studies and authorized by OWRR as a change in objective effective for FY 1966.

The initial principal investigator was Dr. Herbert Riehl. Dr. James L. Rasmussen was appointed principal investigator at the beginning of FY 1969. Professor Lewis O. Grant served as a consultant throughout the project.

Introduction

The idea of artificially controlling the blowing of snow has long fascinated people living in mountainous terrain. The protection from avalanches and roadway maintenance have been two of the objectives of such activity. Recently another dimension has been added in this area of endeavor; that is to control the drift of snow such that hydrologic benefit will result (1) (2) (6). An example of this type of project is the U.S. Forest Service experiments in the central Colorado Rocky Mountains using snow fences to act as the controlling mechanism (8).

The purpose of the project summarized here was to design a snow fence system that would be effective in the intercept of falling snow as well as the channeling mechanism for the drifting snow. The fence system was to be designed for the high alpine tundra region thus the requirement of a portable system was necessary. The design, therefore, had to be lightweight and not cumbersome from the point of view of transportation. The fences also had to be easily constructed without power equipment.

The specific objectives of this research program were:

(1) To design an effective snow fence system that would:
   (a) increase intercept of snowfall
   (b) control snowdrift
(2) To install an operational snow fence system in a location conducive to snow management for hydrologic purposes.

Snow Fence Design

The concept of the snow fence system is one described by H. Riehl (5). Over the period of several winters the details in the design described in this section were developed. Some background in the meteorology of large storm systems is necessary to understand the snow fence concept. The large snow storms occurring over the central Colorado Rockies are typified by a wind shift following the precipitation occurrence. During the period of snowfall the winds are typically southwesterly shifting to northwesterly after clearing takes place. This wind shift is merely the reflection of the "upper trough" associated with the passage of a synoptic scale cyclone. The wind speed at mountain top height increases in magnitude as it shifts to the northwest; this strong northwesterly wind is the wind that drifts the new fallen snow across the high alpine tundra. Figure 1 depicts the snow fence system that evolved from the several winters of testing.

The individual fences consist of a pipe frame, dimensions 10 ft. high by 100 ft. long, on which the fencing material was attached. Figure 2 depicts the construction, materials and dimensions of the frame. Several fencing materials and configurations of materials were tested on the frame for their effectiveness in the dual role required in the overall design. The reader is referred to the work of Pugh and Price (4) and Martinelli (2) for background on fence efficiency. The following is a description of four of the examples tested.

(a) One inch mesh fencing material covering the entire 10 ft. height.

This material proved to be too porous for the trapping function; little variation between the snowfall in the fence zone and in surrounding zones was observed. Further, the snow accumulated at the base of the fence settled and exerted such force on the material that the fences needed constant maintenance.

(b) Three layers of 1 inch mesh fencing material covering the entire 10 ft. height. Average mesh size of 1/2 inch. Density estimated at 40 percent.

This fencing material proved to be an effective trap for snowfall. Figure 3 shows a cross section of snowfall on 2 February 1967 through a field of 3 parallel fences. Again the settling snow, particularly in the spring, took the fences down so that considerable maintenance was needed on the installation.

(c) Two layers of 1 inch mesh material covering the entire fence with two rows of solid (burlap) material, the rows spaced three feet apart and running the entire length of the fence.

Figure (4) shows this configuration during the middle of the snow accumulation season. Figure (5) shows the contours of snow depth at mid-March for this configuration. The fabric material was impregnated with asphalt but even this did not offer enough strength to overcome the weathering experienced during one winter. The effect of the barrier diminished as the season proceeded due to two causes; the accumulation of snow at the base of the fence and also the deterioration of the fabric material.

(d) Two 3 ft. wide rows of 1/4 inch mesh fence material running the length of the fence. The first row was anchored at the top and the second was located 4 feet from the top.

This snow fence design produced a desirable effect with regard to trapping and channeling of the snow, (Figure 6). The base of the fence remained relatively clear of snow due to the scouring effect through the gap next to the ground (2).

The target area noted on Figure 1 was conceived as being some geologic formation situated such that the snow accumulation would be protected from wind and solar radiation thus decreasing the evaporation and increasing runoff or at least extending the peak runoff later in the season (3). One obvious geologic formation for this purpose would be a glacial cirque formation opening to the northeast.

Snow Fence Test--Winter of 1968-1969

Arrangements were made with the U.S. Forest Service, San Isabel National Forest to install a set of snow fences on Buckeye Peak on Chicago Ridge near Leadville, Colorado. The installation was made such that a chute in a glacial cirque was the target area (Figure 7). This choice was made because the land form provided suitable features from which to photograph the accumulation in the target area. The design discussed in part 2 (d) above was constructed at this site. Figure 8 shows the accumulation by December 16, 1968 after but one major snow storm. Note that the accumulations of snow at the snow fences were apparently in excess of those at locations away from the fences. Further evidence of increased volume of snow in the target and fence areas is shown in Figure 9, an aerial photograph of the area on June 1, 1969. The snow density in the target region was compared to the density measured outside the region, both upslope and downslope from the target area. The results, Table I, show a significant difference between the snow densities in the target region as compared to outside regions. The snow accumulated in the target was, on the average, only 78% as dense as that in the natural cornice; thus, the quanity of water per unit volume is less in the controlled drift. A series of sterographic pictures taken of the area did not turn out because of camera malfunction. This feature of the analysis designed to give accurate volumetric measurements will be repeated during the winter, 1969-1970. What was apparent from the experiment was (a) the fence was effective in intercepting the snowfall, and (b) the drifting snow was deposited in the target area yielding increased volume.

Recommendations for Further Research

The snow fence design conceived and tested in this experiment can increase the accumulation in a suitably chosen target area. The hydrologic benefit can only be ascertained if the installation were constructed on a much larger scale, say an order of magnitude larger, and over a hydrologically measured basin (3). Some measure of evaporation from the accumulated snow would be necessary in order to evaluate the potential hydrologic benefit under the employment of evaporation suppression techniques. Thus the recommendations are:

(a) Increase the areal extent of the fences.

(b) Choose a location for installation with a working stream gauge that could be expected to respond significantly to modification effects.

(c) Concurrently, evaluate the evaporation occurring from the snow pack in order to determine a "potential benefit".

TABLE I

SNOW DENSITY OBSERVATIONS OBTAINED ON 1 MARCH 1969.

UNITS ARE gm/cm^3.

	Number of Observations	Range	Average Density
Inside of snow fence target region	6	.43-.36	.41
Outside of snow fence area	13	.70-.34	.52

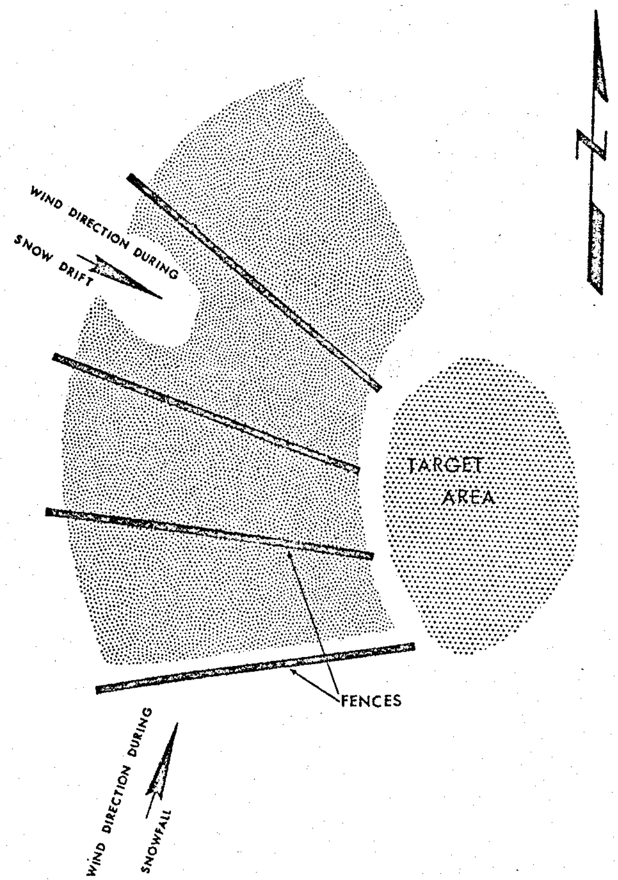

Figure 1. Snow fence system developed to act as a snowfall trap (fine shaded area) and to control the snowdrift.

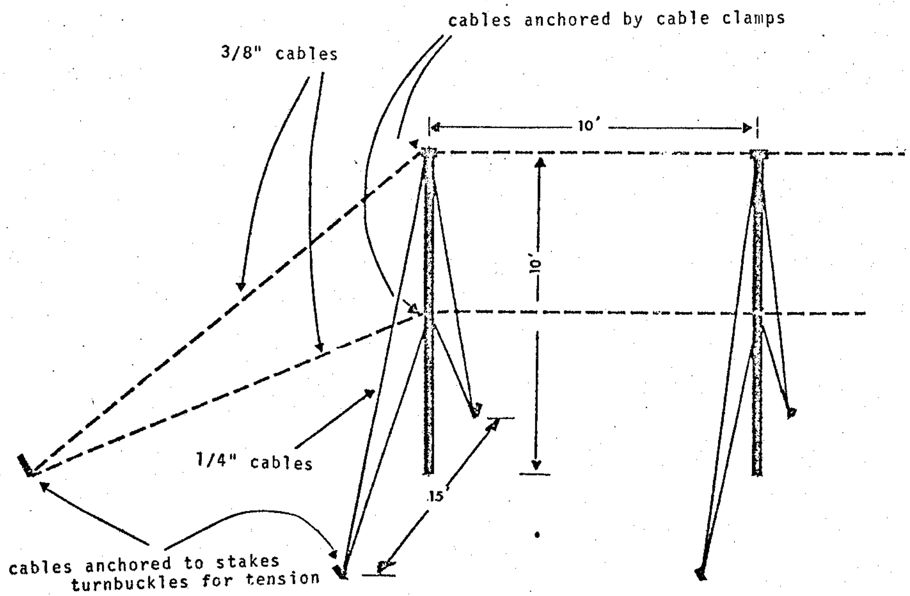

Figure 2. Schematic of snow fence frame used in study.

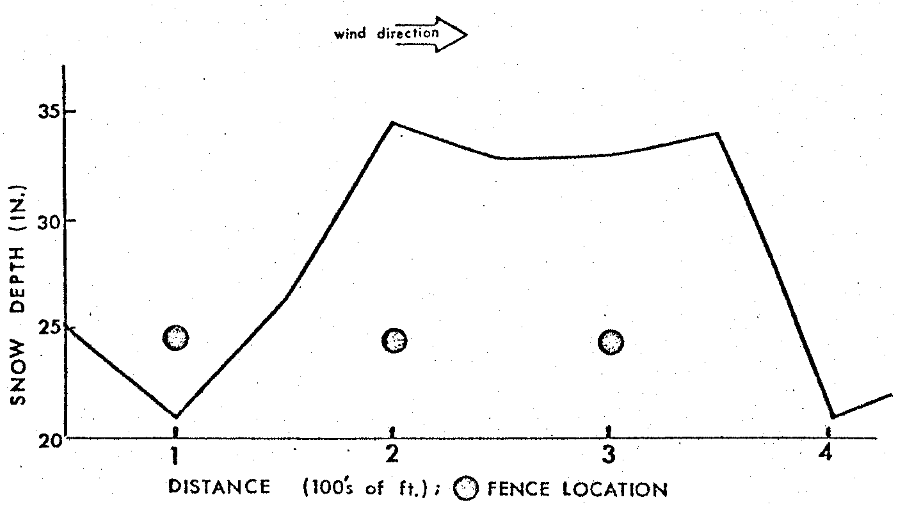

Figure 3. Snow depth profile through the snow fence field. Fences were oriented normal to the plane of the diagram. The dots merely denote the position at which fences intersect the plane of the diagram.

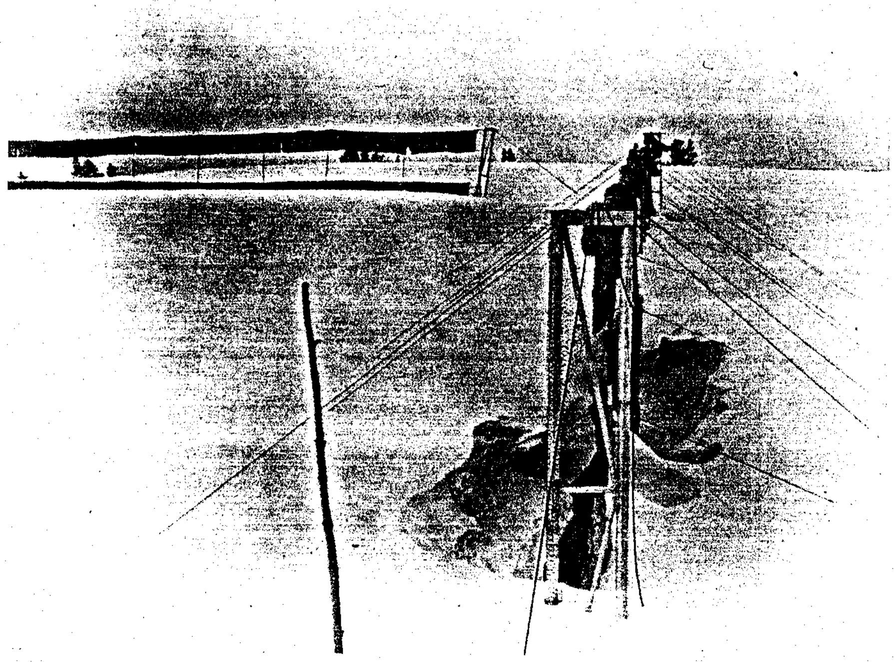

Figure 4. Snow fence installation described in section (c) above.

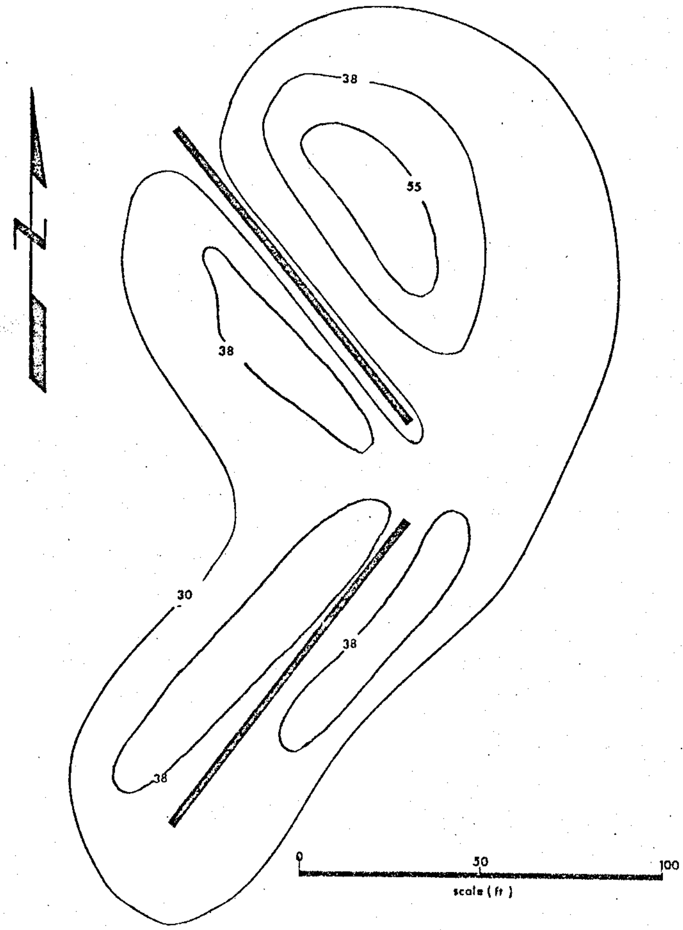

Figure 5. Contours of snow depth in the fence system of section (c) above (see Figure 4). The heavy lines are the position of the fence structures.

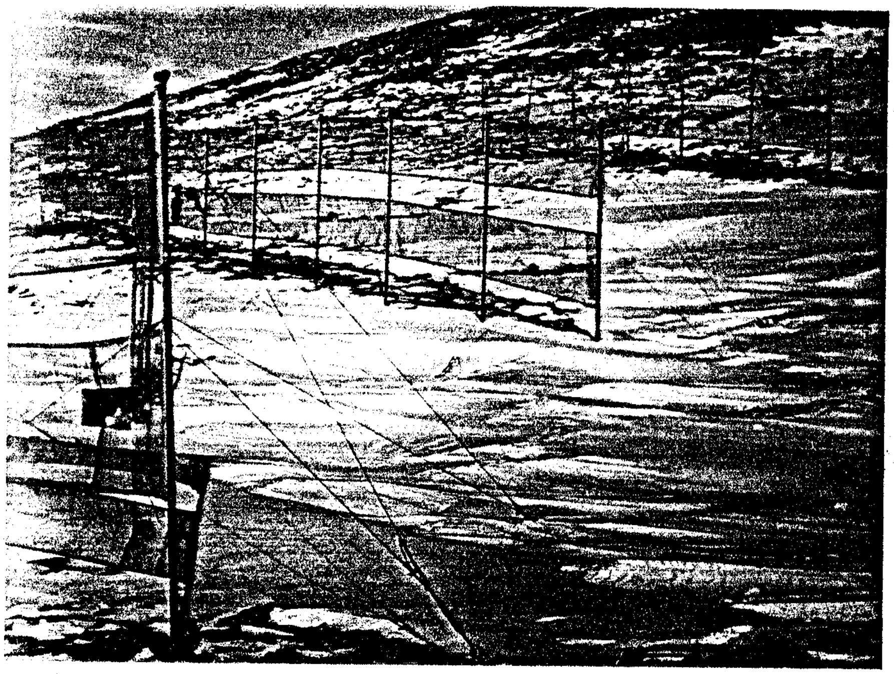

Figure 6. Snow fence system of section (d) above.

Figure 7. Photo taken December 17, 1968 showing topographical form of the target area. Note fence structure above cornice. The overhanging cornice snow formation did not exist the winter prior to the fence installation.

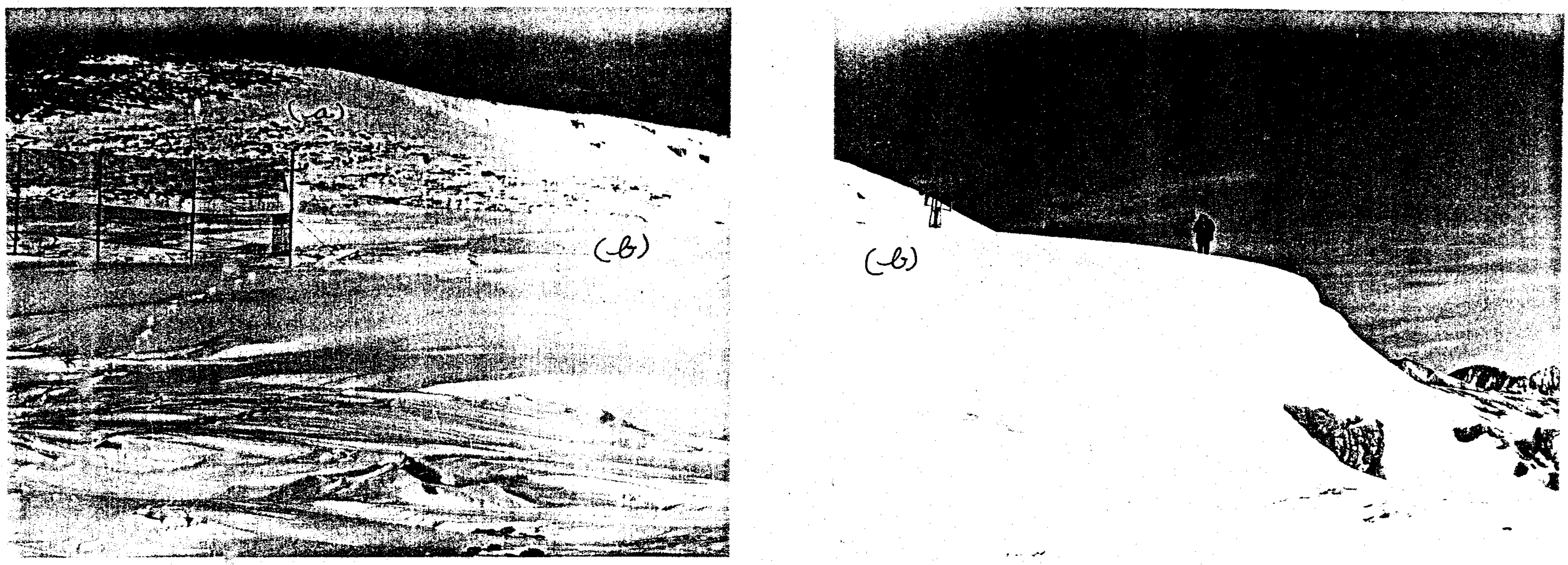

Figure 8. Photos showing the drift of snow accumulated by 16 December 1968 after one large storm. Note the excess accumulation at the fences as compared to areas away from the fences. Virtually no difference in accumulation between (a) and (b) was observed the previous winter. Note that the two photos are partial superimpositons.

Figure 9. Aerial photograph showing snow fence field and snow area on 1 June 1969. Dashed line denotes approximate location of snow line found without fences installed.

REFERENCES

(1) Landsberg, H., 1947: Include climate in highway plans. Better Roads, 17 (3), 25-28.

(2) Martinelli, M., 1964: Influence of gap width below a vertical slot snow fence on size and location of lee drift. Bull. FASH. IX, 4, 48-57.

(3) Martinelli, M., 1965: An estimate of summer runoff from alpine snow fields. Journal of Soil and Water Cons., 20, 1.

(4) Paugh, H. and W.I.J. Price, 1954: Snow drifting and the use of snow fences, Polar Record, 7 (47), 4-23.

(5) Riehl, H., Personal communication.

(6) Select Committee on National Water Problems, U.S. Sen. Comm., Print 21, 1960: Evapotranspiration reduction.

(7) Tabler, R. D., 1968: Physical and economic design criteria for induced snow accumulation projects, Water Resources Research 4,3, 513-519.

(8) U.S. Forest Service, San Isabel National Forest Office, Leadville, Colorado: Personal Communication.