THE USE OF SNOW FENCES FOR SHIELDING PRECIPITATION GAGES

By

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Introduction

The reasons for wanting to measure precipitation are many and varied but basically the data are required as an essential element for climatology, hydrology, and meteorology studies. The purpose of the gage itself is to determine how much precipitation per unit area and per unit time would have fallen to the ground had the gage not been there. Hopefully, with measurements from several gages, it is possible to arrive at an estimate of the total amount of water deposited over a given area of ground.

In the Nineteenth Century, it became apparent that the catch of precipitation gages was affected by many variables, the most important being wind (Abbe, 1887:4). Many investigations from that time on have also shown that wind has a strong influence on gage catch and that an increase in wind speed generally results in a decrease in catch, especially for solid precipitations.

Because wind has such a great effect on the gage catch, many investigators have attempted to develop a wind shield which would eliminate this effect. Several different forms of wind shields were proposed and tried; some were attached to the gage, both inside and outside, while others were separate from the gage (Kurtyka, 1953:29). Even though many designs have been proposed and built, no shield in use today has completely solved the wind problem.

The selection of proper exposure is most difficult and from the literature it would appear that a protected location is one in which the horizontal angle from the gage to the tops of the uniformly surrounding objects would be about 30° (ESSA, 1970:18). If siting can cause a major error in measuring snow, it would appear to be important to be able to provide a "correct" manmade site. The proper shielding of the entire gage and site, therefore, could contribute to the reduction of errors due to poor site conditions.

Objective

The objective of this study is to investigate the possibility of shielding precipitation gages from adverse wind effects by using artificial wind barriers, such as snow fences. If such protection were possible, it would permit standardization of wind shielding, which in turn should make possible more meaningful comparisons of data gathered from gages at different locations within a network.

Installation

The study site is located on Pole Mountain, in the Medicine Bow National Forest, seventeen miles East of Laramie, Wyoming, at an elevation of 8,100 feet. The area is open and subject to frequent winds of relatively high speed and prolonged duration. Figure 1.

Based on knowledge about the functioning of snow fences, it was decided to establish a test enclosure of 4½-foot snow fence, 80 feet long by 50 feet wide. Within the enclosure, five recording-weighing Belfort precipitation gages were installed. Figure 2.

Prior research has shown that the maximum wind reduction behind a snow fence occurs at a downwind distance of approximately five times the height of the fence (Pugh, 1950:24). Therefore, a pair of gages (with and without Alter shields) were set 20 feet (5h) east (downwind) of the westerly fence. To test if the point of maximum wind reduction

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were the best for siting a gage, additional gages were located 10 feet (2.5h), 40 feet (10h) and 60 feet (15h) east of the upwind fence. For ease of reference, the gages were numbered, with gages 1, 2, 3, and 5 placed at 60, 40, 20 and 10 feet, respectively, behind the west edge of the enclosure, all with Alter shields; and gage 4 at 20 feet, but without the Alter shield.

Two precipitation gages, numbered 6 and 7, were placed in the open, with no fence protection in order to provide control data for the study. Number 6 gage is unshielded while number 7 has an Alter shield.

Gage 8 is situated 50 feet behind the fourth in a series of 8½-foot fences. The 50-foot location was chosen because the maximum velocity reduction behind the fence would be in this general area. Gage 9 has been installed inside two concentric circles of snow fences inclined at 45° and 60° angles from the horizontal, similar to what might be called "blow" fences. Figure 3. The design of the enclosure was empirically determined in a wind tunnel, utilizing tufts of string to indicate maximum velocity and turbulence reduction at the orifice of the gage.

Gages 10, 11, and 12 are non-recording gages situated one mile west of the site in small openings within forested areas.

Snow fence material is the standard 4-foot vertical-lath highway-type fencing, with about 50 percent density. This type of fencing was used because it has been found that open fences are superior to solid fences and that the optimum open density is about fifty percent (Pugh, 1950:42). The standard type of fencing was also used so that, if the results of the research were favorable, the availability of materials for other installations would not be a problem. A gap of six inches was left below the fence because other research has shown that a gap of less than six inches allows snow to accumulate against the fence and thus "streamline" it prematurely (Pugh and Price, 1954:9). If the gap is greater than one foot, the snow collecting capacity of the fence may be reduced.

In addition to the instrumentation installed especially for the study, the United States Forest Service, Rocky Mountain Forest and Range Experiment Station has two recording precipitation stations, one approximately one mile east and one approximately one mile south of our site, as part of one of their research efforts. These gages, referred to as USFS-1 and USFS-2, are situated in small openings within forested areas and it is felt that they are installed approximately as recommended by the National Weather Service and could provide a "standard" against which the test gages could be compared.

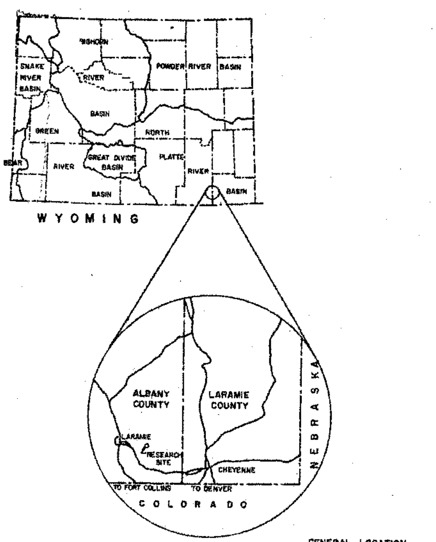
It was recognized that site shielding involved a problem of attempting to minimize windspeeds and turbulence without inducing the catch of drifting (relocated) snow. More than 90 percent of the blowing snow has been shown to be contained within the first meter above the ground (Mellor, 1965:15). Therefore, the orifice of all gages was placed more than one meter high. It was felt that the Alter shields would prevent the snow which might hit the sites of the gage from being lifted up to orifice height and caught. To reduce the amount of snow being transported past the gages, the main test enclosure was provided with additional protective fences upwind. The fences are to trap the blowing snow and prevent it from being lifted to orifice height.

<u>Preliminary Data Analysis</u>

<u>Precipitation Data from All Gages</u> -- The total amount of precipitation caught during the periods October 1969 to May 1970 and September 1970 to January 1971, by each precipitation gage at the research site and by the two Forest Service gages, is summarized in Table I. Because there was evidence of snow blowing into gages 3, 4, and 5 during some of the weekly periods during the winter 1969-1970, an estimated catch was used to arrive at the "adjusted" values for those weeks. No adjustments are necessary on the data from the other gages nor were adjustments necessary for the data from the 1970-1971 period.

The weekly data from all gages are plotted as a mass curve of precipitation for the two periods, as shown on Figures 4 and 5. Some interesting results are immediately apparent from these graphs.

Precipitation gage 6, which has no Alter shield and no fence protection, caught the least amount of precipitation during both periods of time. This is as would be expected and reinforces the argument for an Alter shield on all gages.



GENERAL LOCATION
POLE MOUNTAIN SNOW FENCE
RESEARCH SITE
W.R.R.I. UNIVERSITY OF WYO.
JULY 1970

FIGURE 1

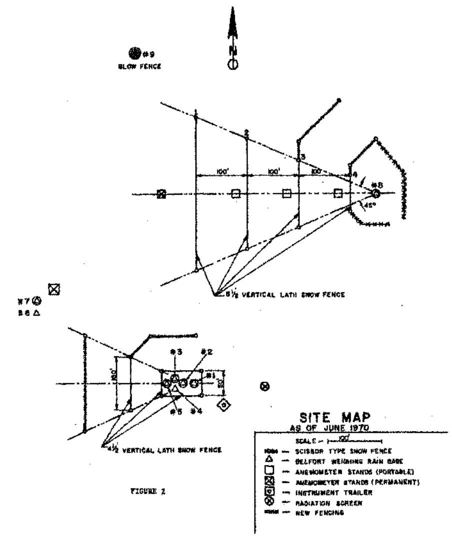


FIGURE 2

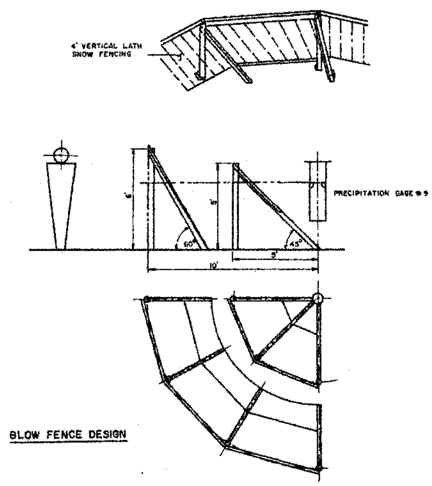


Figure 3

TABLE I

TOTAL PRECIPITATION CAUGHT BY GAGES

Gage Number	Gage Distance from Upwind Fence (feet)	Alter Shield Provided	2 Oct 1969 - 28 May 1970 Recorded Precipitation Inches	cm	%"standard"	Gage Number	1 Sept 1970 - 31 Jan 1971 Recorded Precipitation Inches	cm	%"standard"
1	60	Yes	13.69	34.77	103.5	1	6.97	17.70	100.5
2	40	Yes	13.71	34.82	103.7	2	7.21	18.31	104.0
3	20	Yes	*16.15	41.02	122.1	3	7.52	19.10	108.5
4	20	No	*** 9.99	25.37	75.5	4	5.73	14.55	82.6
5	10	Yes	**13.31	33.81	100.6	5	7.36	18.69	106.2
6		No	5.05	12.83	38.1	6	3.84	9.75	55.4
7		Yes	8.95	22.73	67.7	7	5.29	13.44	76.3
8	50	Yes	10.71	27.20	81.0	8	7.80	19.81	112.5
						9	6.38	16.21	92.0
						10	7.11	18.06	102.5
						11	6.66	16.92	96.1
						12	6.82	17.32	98.4
USFS-1		Yes	13.22	33.58	100.0	USFS-1	6.93	17.60	100.0
USFS-2		Yes	15.01	38.13	113.5	USFS-2	7.73	19.63	112.0

*Estimated values for 5 weeks during the period
**Estimated values for 4 weeks during the period
***Estimated values for 1 week during the period

Some changes were made in the site layout during the summer of 1970 to correct for deficiencies in design observed during the 1969-1970 winter. It was obvious that gage 8 was receiving very little protection from north and northwest storms, therefore the 8½-foot fences were extended to the north to afford additional protection. The effect of this modification is apparent in the comparison of the catch by the protected gage during the two winter periods. For 1969-1970, gage 8 averaged 81 percent of the standard catch while, for the first part of the winter season 1970-1971, it is now averaging 112.5 percent.

During the first year of operation, major drifting was experienced around gages 3, 4, and 5. For this reason, an additional 8½-foot fence was placed 150 feet west of the test enclosure with apparently satisfactory results. The catch of gage 5 dropped from 118.6 percent to 106.2 percent of the standard. That by gage 3 dropped from 134 percent to 108 percent and by gage 4 increased from 78.8 percent to 82.6 percent. Observations during the early portion of the winter 1970-1971 show that there is now very little drifting around these gages.

Among several multiple comparison tests available for identifying differences between performances, the Duncan multiple-range test was chosen (Miller and Freund, 1965: 279-283). This analysis shows that the gages fall into one of three groups as far as performance is concerned. Group one (gage 6) has no protection. Group two (gages 4 and 7) have one method of protection, either shield or fence but not both. Group three (gages 1, 2, 3, 5, 8, 9, and USFS-1) have a shield plus some other protection, either fences or trees.

<u>Wind Effect on Gage Catch</u> -- The study site was subjected to prevailing northwest winds most of the year and particularly from October to May. An analysis of the wind speeds accompanying storm events was felt to be important.

Figure 6 is a plot of the ratio of the catch of gages 2, 6, 7, and 9 to the "standard" versus wind speed. It shows that gage 9 (blow-fence) is less affected by an increase in wind speed than gages of other shielding configurations.

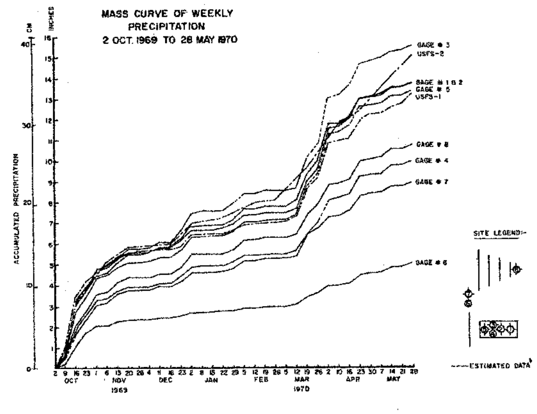


Figure 4

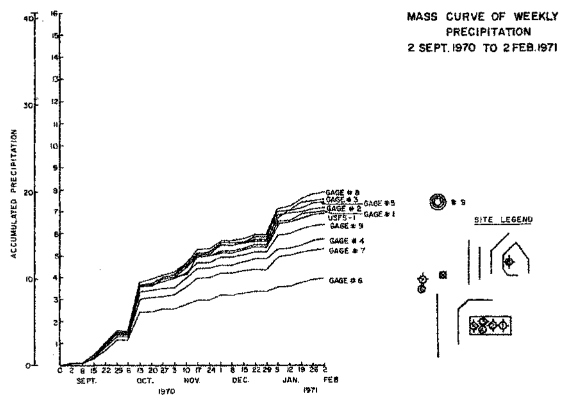


Figure 5

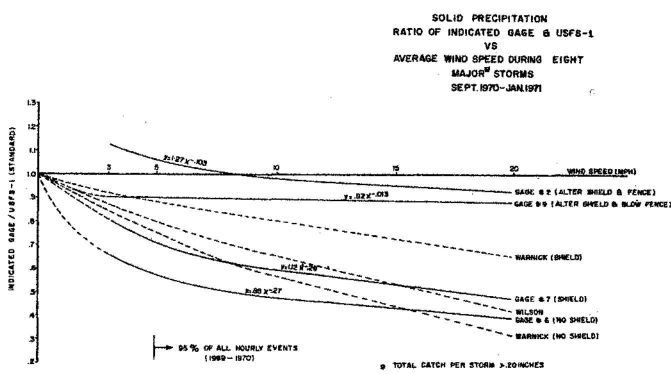


FIGURE 6

Conclusions

The function of the fence-shield combination is to provide protection to the gages from both site and gage eddies. Without protection, these eddies influence the manner in which the precipitation falls, with the extent of the influence partially dependent upon the form and nature of the precipitation (i.e., drop diameter, crystal type, etc.) (Weiss and Wilson, 1957: 464-465). It would seem that the snow fences have provided effective protection against the site eddies, at the research location studied. It is not our contention that site shielding such as used in this study will be applicable for all sampling situations. As an example, the deep snows with less wind experienced in the California mountains might not be amenable to the same shielding as experienced in the Rocky Mountain area.

While comparisons of gage catch reported on herein might imply that the gage which caught the most snowfall would be "best", it is not intended that the largest catch would be the criterion for the tests, because it cannot be categorically stated that the greatest catch is necessarily "true" catch. Uniformity of catch characteristics for all conditions, however, is desirable so that more meaningful comparisons can be made among gages at different locations.

It does seem that fences can provide site protection approximately equal to a "well-protected" site. All the gages from the Duncan interval group "three" (which includes the "standard") have a combination of fence protection, i.e., drifting of snow into the gages from fence eddies, appears to be controllable through the use of upwind fences to capture the snow before it is transported past the gages. Sixteen mm time-lapse photography of the site enclosure and weekly visual observations have revealed little or no drift build-up around any of the test gages during the winter 1970-1971.

In general, preliminary data analysis indicates that, under windy conditions, an unshielded precipitation gage will catch about one-third of the "standard" snowfall, a gage with its orifice protected by an Alter shield or with site protection by a snow fence, will catch about two-thirds of the "standard", while a gage with both its orifice and site protected will catch about the equivalent snowfall of the "standard".

ACKNOWLEDGMENTS

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Use of company or brand names herein is made to better describe the instrumentation and the facilities. A recommendation by the University of Wyoming or the National Weather Service is not to be implied.

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