# DETERMINING VARIABILITY OF SNOW ACCUMULATION AND ABLATION ON WESTERN RANGELANDS

785-85

BY

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## INTRODUCTION

Snow accumulation and melt on western rangelands are often extremely variable over even relatively small areas, because wind plays such a dominant role in snow distribution. This variability in distribution causes problems in: 1) determining flood and water supply relationships; 2) roadway design and maintenance; 3) livestock and wildlife management and operations; and 4) application and verification of snowmelt models. Our interests were mainly associated with snowmelt modeling, which could provide answers for dealing with the other three areas of concern. Some hydrologic models ignore the effects of snow, but most contain very simple empirical relationships between air temperature and a coefficient to account for precipitation falling as snow, and snow water in storage. Application of the models generally requires that snow distribution over the area of consideration be homogeneous. Thus even relatively small rangeland watersheds must be divided into hydrologic response units to account for variations in snow distribution.

This study was designed to determine variability in snow distribution and melt on a 26 ha site on the Reynolds Creek Experimental Watershed (Robins et al., 1965) located in southwestern Idaho. Results will be used to develop ways of addressing some of these problems.

## DESCRIPTION OF STUDY SITE

The 26 ha Upper Sheep Creek site used in this study is an upstream source area located on the east side of Reynolds Creek, which ranges in elevation from 1840 to 2036 m. The basin is about 850 m long by 400 m in width with a southeast to northwest drainage through the center, and a relatively steep 25 percent average slope. The primary runoff for the basin usually occurs from January through July, and is generated by snowmelt from deep drifts on the northeast-facing slopes. Average annual precipitation is about 400 mm. Vegetation varies in response to soils and moisture distribution, and includes sagebrush, grasses, shrubs, and aspen thickets. The Upper Sheep Creek soils developed from basaltic parent material and vary considerably in depth and profile development depending on aspect and micro-climate (Stephenson, 1977).

## DATA COLLECTION AND ANALYSIS

Instruments designed to continuously monitor precipitation, incoming solar radiation, wind direction and speed, air temperature, relative humidity, snowmelt (snowpack outflow), and soil moisture and temperature at four depths have been in operation for one season. In addition, snow depth and snow water equivalent measurements at 30 and/or 60 m grid spacings, and aerial photos were obtained at approximately two week intervals during the snow accumulation and melt period. Preliminary analysis of three facets of the project are described below, using the snow depth, snow water equivalent, snowmelt, and aerial photos.

### Snow Sampling

The variability in snow distribution on the watershed was determined from standard snow tube samples taken at 30 m and/or 60 m spacing. The 60 m grid (71 points) was part of the 30 m grid (274 points) shown in Figure 1. Manpower limitations were such that a 30 m grid sample required two days to accomplish, and sampling criteria dictated that the two days be storm free so that measurements on the different days would be comparable. During the 1983-84 winter season, the 30 m grid was sampled eight times and the 60 m grid was sampled six times. Since the surface at the grid point was often bare or only partly covered, special care was taken to determine an average depth, and an estimate of the area covered by snow.

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Considerable variation in both depth and density was found. The snow depth varied from zero on the windswept ridges and southwest-facing slopes, to over 3.9 m in the drifts on the northeast-facing slopes at the time of maximum accumulation (first week in April). Density for this same period ranged from 15 percent in new shallow snow to 46 percent in the deep drifts which accumulated during the snow season.

Since the 60 m grid was part of the 30 m grid, it was possible to compare results produced using the two different scales. Figures 2a and 2b show the snow water equivalent distribution on February 9, 1984 for the 60 m and 30 m grids, respectively. The 30 m grid map shows considerably more detail, as expected. The total volume of water in storage within the snowpack was determined using both grid scales for five different sampling dates during the 1983-84 and 1984-85 winter seasons. The results (Table 1) indicate that the total volume of water on the watershed as determined using 60 m grid data was up to 20 percent less than that determined using the 30 m grid data. Differences of this magnitude could be significant when attempting water balance studies or using the expected snowmelt as input to hydrologic models.

### Aerial Photographs

In addition to the snow tube samples, aerial photographs showing the snow coverage on the basin were taken at about two-week intervals during the melt season (from late March through June). Analysis of the aerial photographs consisted of determining the percentage of areal snow coverage for each photo date using video image analysis equipment. The standard snow sample grid data can also be used to estimate areal snow coverage by relating the grid points with snow cover to total grid points. Results for two dates when aerial photos and grid samples at both scales were available are presented in Table 1. The percent snow cover determined from the aerial photos, and the two grid scales are in close agreement.

### Snowmelt Collectors

Five ground level snowmelt (snowpack outflow) collectors were installed at 15 m intervals on a transect (Figure 1) perpendicular to and running through the main drift. The collectors consist of standard 203 mm diameter raingage receptacles placed such that the rim is about 25 mm above the ground surface. Melt water collected in the receptacle flows down slope beneath the ground in a plastic pipe into a heated instrument shelter and through a raingage tipping-bucket mechanism. Each tip of the bucket is recorded on an automatic data acquisition system, thus providing rate and volume of snowmelt. Two of the collectors are downhill from the main drift, two are under the main section of the drift, and the remaining collector is under the upper edge of the drift (Figure 3). The depth of snow along a parallel transect on March 8, 1984 is shown in relation to the collectors and instrument shelter in Figure 3.

Figure 4 shows the accumulated daily (midnight to midnight) snowmelt recorded for each collector. The pattern of the volume of melt water collected corresponds closely to the depth of snow indicated above the collectors in Figure 3. It is interesting to note that all of the snow beyond the main drift was melted before significant melt began at collector #4 under the deepest part of the drift. The maximum rate of outflow recorded was 184.7 mm/day on May 29, 1984 (midnight to midnight) at collector number 4.

## SUMMARY AND CONCLUSIONS

Equipment and procedures were described for determining snow accumulation and melt under extremely variable conditions found on windswept rangelands. Preliminary analysis of one season's data illustrates the variety of conditions encountered, intensity of sampling required, and the adequacy of the installation and procedures developed. The data collected offers the possibility of establishing areal accumulation, areal depletion, and melt relationships. Results indicate that 30 m grid samples produce better estimates of areal coverage and basin snow storage than 60 m grid samples. This type of data could also be used as ground truth information for verifying remotely sensed snow water equivalent when instrumentation becomes available.

## ACKNOWLEDGEMENT

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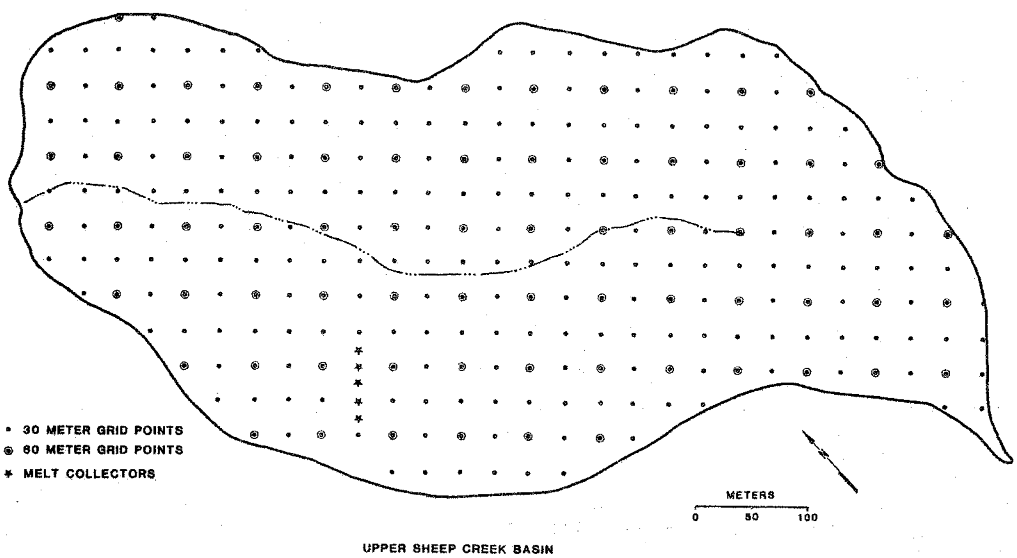


Figure 1. Upper Sheep Creek Watershed showing 60 m and 30 m grids, and melt collectors.

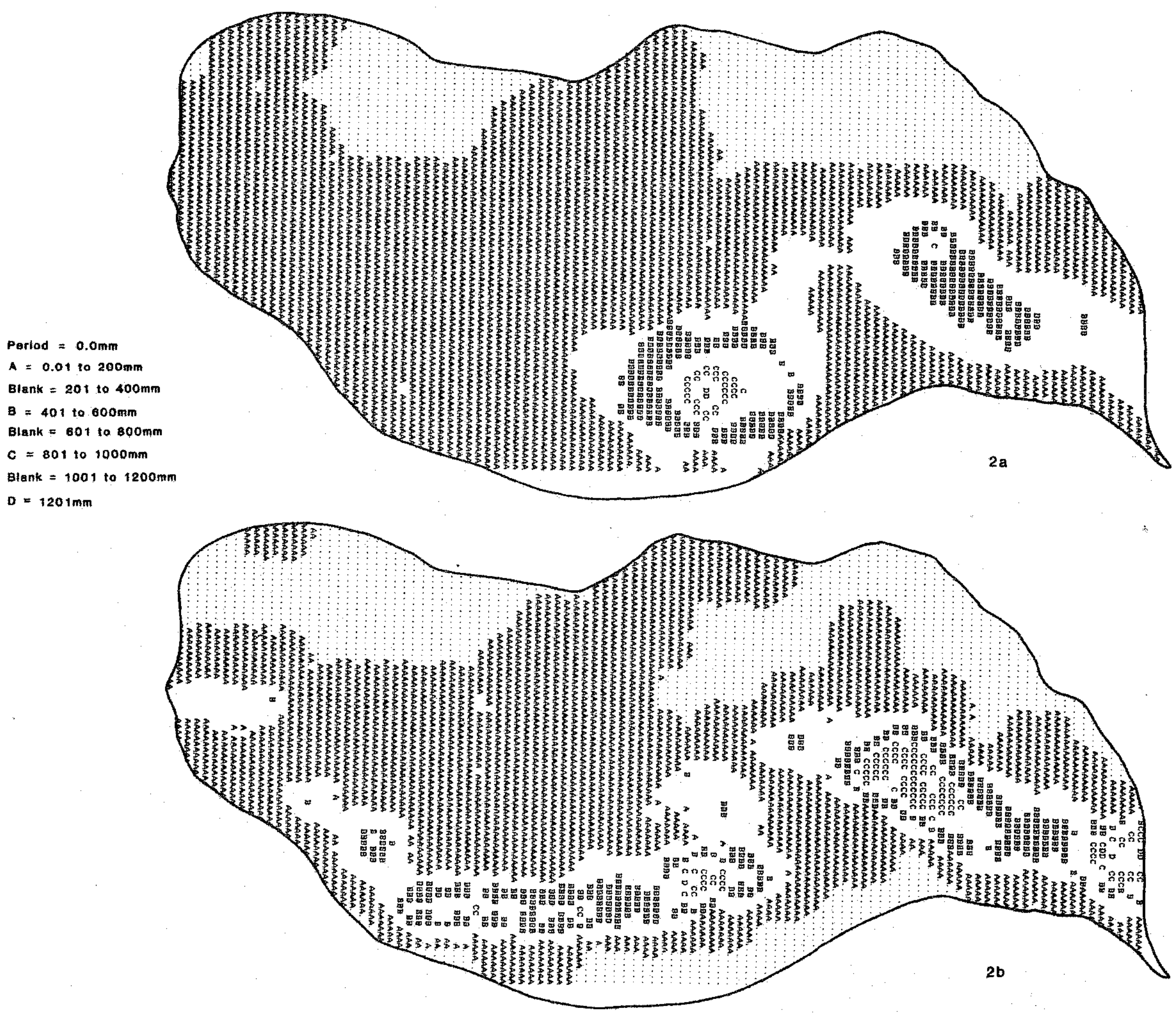


Figure 2. Snow water equivalent as determined from hand samples on a 60 m grid (2a) and a 30 m grid (2b) at Upper Sheep Creek Watershed on February 9, 1984.

## REFERENCES

Robins, J. S., L. L. Kelly, and W. R. Hamon, 1965: Reynolds Creek in southwest Idaho: An outdoor hydrologic laboratory, Water Resour. Res. 1(3):407-413.

Stephenson, G. R., ed., 1977: Soils-geology-vegetation inventories for Reynolds Creek Watershed. Univ. of Idaho Agri. Exp. Station, Misc. Series No. 42, 73p.


Table 1

Total snow water equivalent in storage determined from 30 m (274 points) and 60 m (71 points) grids in cubic meters

| | Sample Date | | | | |
|---|---|---|---|---|---|
| Grid Spacing | 2-9-84 | 4-4-84 | 5-7-84 | 1-8-85 | 1-22-85 |
| 30 m | 42390 | 68650 | 41920 | 32560 | 31590 |
| 60 m | 36890 | 64790 | 37370 | 26130 | 25470 |
| % Difference | 13 | 6 | 11 | 20 | 19 |

Table 2

Percent of snow covered area determined from aerial photos and 30 m and 60 m grid samples

| Sample Date | Method Applied | | |
|---|---|---|---|
| | Aerial photo | 30 m grid | 60 m grid |
| 5-7-84 | 36 | 33 | 31 |
| 6-14-84 | 5 | 5 | 6 |

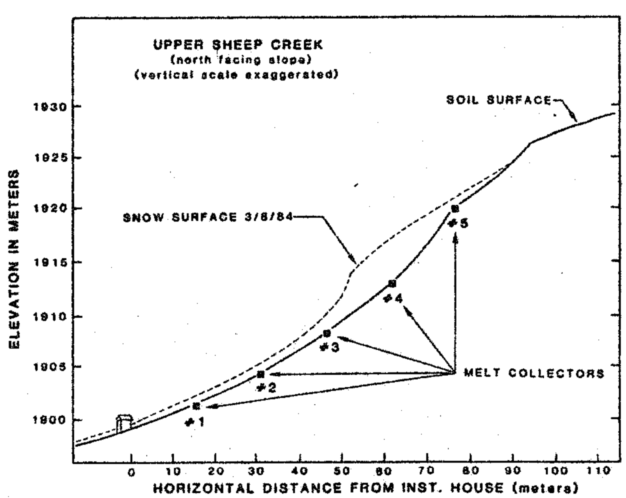


Figure 3. Soil and snow surface profiles on north-facing slope, melt collectors, and instrument shelter for March 8, 1984, at Upper Sheep Creek Watershed.

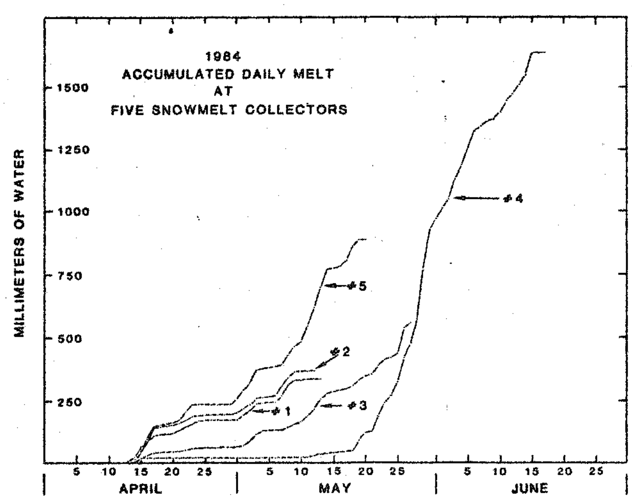


Figure 4. Accumulated daily snowmelt collected on north-facing slope of Upper Sheep Creek Watershed during 1984 (mm).