JOURNAL OF HYDROLOGY (N.Z.) Vol. 9, No. 2, 1970

LOCAL SNOW DISTRIBUTION IS NOT A FUNCTION OF LOCAL TOPOGRAPHY UNDER CONTINUOUS TREE COVER

R. H. Swanson*

ABSTRACT

Timber management to enhance water values is a desirable practice. Vast timbered areas, such as the Forest Reserves of Alberta, cannot be managed to too fine a degree under the present economic conditions. Therefore, general guidelines are desired.

The enhancement of local ground-water recharge systems through snow accumulation management would seem to be a desirable practice for the approximately 6,000 square miles of lodgepole pine and mixed aspen timber types of the Forest Reserve. This topographically and vegetatively uniform area is one of low surface-water discharge, but high importance in ground-water recharge.

Results of snow measurements made in Deer Creek experimental basin suggest that topographic features do not influence where snow accumulates. An analysis of variance shows slope and crown closure to be nonsignificant for the two data periods. Elevation was significant one month, but not the next. Only aspect was significant both months, but different aspects contributed to the significance each time.

Results are cited from a similar study on Marmot experimental basin which concluded that none of the usually measured topographic features are very useful in explaining snow accumulation variance. The combined results imply that local snow accumulation is not a function of local topography under a continuous vegetative cover, and that general management guidelines could be drawn up for managing snow accumulation without regard to topographic variables.

INTRODUCTION

The Forest Reserves of southwestern Alberta and the adjacent green zone contain roughly 6,000 square miles of mixed aspen and lodgepole pine vegetation type. This timber is reasonably uniform in height and crown-closure density. The underlying topography is also fairly uniform. The elevation progressing from east to west is from 1,200 to 1,700 meters in 160 kilometers. There is little surface water discharge from this area. It is a region of

* Research Scientist, Canada Department of Fisheries and Forestry, Canadian Forestry Service, Edmonton, Alberta.

local and regional ground-water recharge, and thus important from the overall water-management standpoint.

Increasing local snow accumulation would seem to be a desirable water-management practice throughout this area. Effectively localized snow melts over a longer time period, and the meltwater may have a greater infiltration-to-recharge opportunity than that dispersed either in large openings or under the forest canopy. Snow normally accumulates in greater amounts in openings in vegetation, on the lee side of ridges, and in draws and gullies than under the forest canopy. The snow in draws and gullies usually melts and becomes direct runoff. That on the ridges and under the forest canopy may become either surface runoff or infiltrate to become part of the soil water system.

The Forest Reserves could be managed to alter snow distribution patterns. Since openings of any size normally accumulate greater amounts than the surrounding uncut areas, such openings, created on ground-water recharge areas would enhance the local, and perhaps regional ground-water supply. However, in the current forest-management practice in Alberta, the placement of cutting boundaries, and the regulation of the size and shape of opening, is not governed by physical considerations or topographic features, but by timber volume and harvesting economics.

With respect to snow management, a question asked by forest managers is, "is there some general guideline for the shape, size and orientation of forest cuttings that will be suitable for watershed purposes?" The research answer to this question is usually no; that each catchment must be managed as a separate entity; that topography overrides vegetative characteristics in determining snow-management schemes. However, Golding, in a study of snow accumulation distribution within the timbered portion of Marmot experimental watershed, concluded that none of the normally measured topographic variables — slope, aspect, or elevation — were very satisfactory in explaining the snow-distribution patterns noted (Golding, 1970). In fact, these variables or combinations of them, explained less than 17% of the variation. Marmot is topographically "rough" (Fig. 1). The average slope is 39%. If topography as measured did not materially influence snow distribution on Marmot, then perhaps in the more uniform lodgepole pine forested area (Fig. 2), topography is even less important in modifying the accumulation regime.

Accumulation is only half of snow management, but it is an important half. If accumulation within the lodgepole pine type can be managed without undue concern for topography, then the

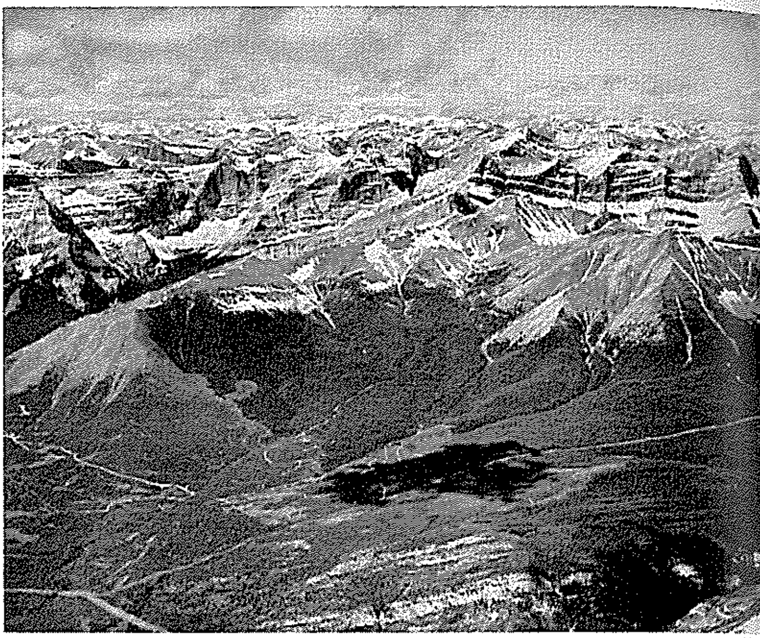

FIG. 1 — Oblique photograph, Marmot experimental watershed.

job of the land manager becomes much easier. Only those factors that alter the melt regime need influence his management plans.

Deer Creek experimental basin lies within the lodgepole pine forested zone of Alberta. It is typical — that is the vegetation and topography within Deer Creek can be found elsewhere throughout this zone — but it is not necessarily representative. Periodic, casual observations in this basin support the same conclusion that Golding reached for Marmot: that topographic features do not markedly influence snow distribution. This led to the study reported here in hope of adding more weight to the casual observations. These observations also led to a working hypothesis:

> Given a continuous tree cover, local snow-accumulation amounts are uniform and not related specifically to any local topographic variable.

The usefulness of this hypothesis hinges on the following implied assumption: if snow is uniformly distributed over the timbered portion of a watershed before cutting, then openings of a given size, wherever they are created on the watershed, will all be equally effective in enhancing the amount of snow that accumulates within them. This assumption was true at Fool Creek experimental watershed in Colorado (Hoover and Leaf, 1967).

FIG. 2 — Oblique photograph of foothills forests. Lodgepole pine harvest cutting patterns in the foreground contrasted against the spruce fir forest on the steep slopes in the background.

METHODS

Deer Creek experimental basin in contrast to Marmot is topographically 'smooth'. The average slope is 25%. Elevation ranges from 1,370 to 1,770 meters with an average of 1,580 meters. The basin faces generally south to southeast. It lies wholly within the lodgepole pine forest type, although scattered spruce and fir are found in the basin. Snow data are from a randomly selected, circular snow course traversing the entire watershed. Snow water equivalents were sampled monthly over a 95-point snow course that sampled all aspects, slopes, elevations, and crown closures. Each 'point' is 5 chains long (1 chain = 20.12 meters); a measurement value for each 'point' is an average of five individual observations made at 1-chain intervals centered on the point. All observations were made using the United States Department of Agriculture snow-sampling kit — commonly called the Mount Rose snow sampler. These data are displayed in Table 1.

RESULTS

These data show no significant difference between the mean water equivalents accumulated on any slope or under any crown closure, than that of the entire watershed. Snow accumulations are significantly different between aspects for both months. However, the aspects accumulating the greatest and least are not consistent between the two data periods. In February, east and west aspects received the greatest and least respectively, while in March, northeast and south took the honors. The normally reported increase in accumulation with elevation is evident in February, but nonexistent in March. Neither month was subject to much advective energy input, as 1969 was a year with very few chinooking periods, and these not intense.

TABLE 1 — Average snow water equivalents in millimeters, 1969 data.

	Aspect							
Date	*N*	*NE*	*E*	*SE*	*S*	*SW*	*W*	*NW*
11 Feb	45.7	51.3	53.1	48.8	48.3	43.9	39.4	47.0
6 Mar	67.7	75.7	70.1	63.2	56.9	60.4	67.0	70.5

	Slope (percentage)				
Date	*00–09*	*10–19*	*20–29*	*30–49*	*50–69*
11 Feb	51.2	47.2	50.2	44.8	45.7
6 Mar	65.3	63.5	65.0	65.5	67.6

	Elevation (meters)					
Date	*1370–1430*	*1430–1490*	*1490–1550*	*1550–1610*	*1610–1670*	*1670–1730*
11 Feb	43.8	47.8	42.3	48.8	48.5	54.9
6 Mar	65.1	62.0	64.7	67.0	62.8	66.0

	Crown closure (percentage)						
Date	*00–09*	*10–19*	*20–29*	*30–39*	*40–49*	*50–59*	*60+*
11 Feb	52.1	47.2	44.7	48.2	47.8	47.1	49.3
6 Mar	72.4	64.8	67.7	65.5	63.2	62.4	67.1

TABLE 2 — Statistical values for analysis of variance.

Date	*Aspect MS*	*Error MS*	*F*	*Significance*
11 Feb	230.77	85.61	2.70	significant
6 Mar	396.39	87.99	4.50	highly significant
Date	*Slope MS*	*Error MS*	*F*	
11 Feb	115.35	97.55	1.18	nonsignificant
6 Mar	28.26	113.69	0.25	nonsignificant
Date	*Elevation MS*	*Error MS*	*F*	
11 Feb	284.58	86.06	3.31	significant
6 Mar	56.71	114.26	0.50	nonsignificant
Date	*Closure MS*	*Error MS*	*F*	
11 Feb	31.48	103.10	0.30	nonsignificant
6 Mar	63.42	113.74	0.54	nonsignificant

DISCUSSION

There is no such thing as proof of a hypothesis such as that advanced here. About all that can be said is that the variables measured did not well explain the phenomenon, the inference being that the hypothesis is true. However, one should look for other evidence of descriptive parameters to support or deny the hypothesis. More work is needed in describing watersheds and their vegetative cover in physically quantifiable terms than can be used to predetermine the outcome of forest land-management activities.

The importance of any hypothesis rests on its end use — to manage forest lands for water. The results gleaned from experimental watersheds are usually couched in finely detailed descriptions of topography and vegetation. Such detailed information is not generally available for areas outside of the experimental basins. If the detailed descriptions are necessary for application of the results, then under the current economic conditions, they will not be used. On the other hand, if it can be shown that the results can be generally applied without additional detailed inventories, then they have a good chance of becoming practice.

The primary purpose for establishing experimental watersheds in Alberta was to learn how to manage the Forest Reserves for water supply, both protection and improved production. Thus the ultimate goal of the research on these experimental watersheds should be useful management guidelines that can be practised.

The above results from Deer Creek are indicative of the kind of information land managers desire. Unfortunately, Deer Creek is a single sample. Thus there is no statistical base for extrapolation of these results. However, the similarity of results obtained on the rougher topography of Marmot makes somewhat reasonable an assumption that results would be similar elsewhere in the Forest Reserve. A third study now underway in the flat terrain to the east of Deer Creek may provide sufficient base for such extrapolation.

CONCLUSIONS

The purpose of this research was to see if the differences in slope, aspect, elevation and crown closure that occur within Deer Creek experimental basin were important in determining where snow accumulates. The evidence presented suggests they are not. On this basin, which is within the lodgepole pine forest type, aspect and elevation were significant during one data interval, but elevation became nonsignificant for the next and different aspects contributed to the significance than for the previous month. Slope and crown closure were nonsignificant either month.

This sample implies that local snow-accumulation amounts are not highly influenced by topography or vegetative canopy density under a continuous tree cover.

REFERENCES

Golding, D. L. 1970: Computer mapping of the Marmot Creek snowpack and the influence of topographic and forest stand variables on the pack. *In*: Powell and Nolasco (Eds.) *Proceedings of the Third Forest Microclimate Symposium*. Canadian Forestry Service, Edmonton, Alberta. pp. 76–83.

Hoover, M. D.; Leaf, C. F. 1967: Process and significance of interception in Colorado Subalpine forest. *In*: Sopper and Lull (Eds.) *Forest Hydrology*. Pergamon, Oxford. pp. 213–224.