

SNOWPACK MANAGEMENT ON MARMOT WATERSHED TO  
INCREASE LATE SEASON STREAMFLOW

by

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INTRODUCTION

Forest cutting has a pronounced effect on water yield. In areas where runoff from accumulated snow occurs as a spring freshet, clearcutting in patches from 0.5 ha to 100 ha has generally increased annual water yields by 20 - 30 percent, most of which occurs during spring runoff.

Numerous studies have related snow accumulation to clearing size. Hoover and Shaw (1962) reported that a clearing is most effective as a snow trap if it is from 2 to 10 tree heights (H) wide, Kittredge (1953) found maximum accumulation in 1 H clearings, Stanton (1966) in 8 to 16 H clearcut blocks. Stanton (1966) observed, as most have, that snow disappeared faster in the clearcut blocks than within the forest.

Golding and Swanson (1978) further quantified the effect of various sizes of forest clearings on both snow accumulation and ablation rate. They measured snow accumulation and ablation in 0, 1/4, 1/2, 3/4, 1, 2, 3, 4, 5 and 6 H circular clearings in 20 m tall lodgepole pine forest on level terrain in Alberta and found that maximum accumulation occurred in 2 H clearcuts, slowest ablation occurred in 1 H clearcuts, Table 1.

Table 1. Snow accumulation and ablation rate in forest clearings 0 to 6 tree heights across. Both accumulation and ablation expressed as percent of uncut (0 H).

	Opening diameter - tree heights (H)									
	0	1/4	1/2	3/4	1	2	3	4	5	6
Accumulation	100	114	120	134	138	145	143	134	134	132
Ablation rate	100	90	82	79	76	88	100	101	105	103

Church (1912) proposed a forest that would be ideal from the standpoint of the conservation of snow would be one "...not..dense enough to prevent the snow from reaching the ground and yet should be sufficiently dense to afford ample shelter from sun and wind". He suggested that such a forest, when viewed from above, would resemble a "gigantic honeycomb".

Golding and Swanson's (1978) data suggest that Church's (1912) ideal forest may not only accumulate more snow on the ground in the interspersed clearings, but that the accumulated snow may also melt at a slower rate than that in an uncut forest.

It is not practical to cut forests in 1 H circular clearings. However a watershed test of this treatment could possibly fill a gap in current forest hydrology management options. If the retarded snowmelt resulted in augmented recession rather than augmented spring freshet flow, then other more practical cutting techniques might be developed to provide "a recession management" option for the watershed manager. With this in mind, the Alberta Watershed Research Program imposed a honeycomb treatment on Twin sub-basin, Marmot Creek Experimental Watershed, Alberta, in 1977 - 1979, Figure 1.

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## MARMOT CREEK

The Marmot Creek Experimental Watershed is located about 80 km west of Calgary, Alberta, in the Kananaskis River valley. It has three sub-basins, Twin (2.64 km<sup>2</sup>), Middle (2.85 km<sup>2</sup>) and Cabin (2.12 km<sup>2</sup>). Cabin received commercial clearcutting in 1974, Twin received the honeycomb treatment. Middle remains as the uncut control. Aspect of Twin is northeast to east, elevation 1670 to 2800 m, annual precipitation 1030 mm (75% as snow), annual runoff 600 mm Storr (1970). Vegetation is principally Engelmann spruce and lodgepole pine.

### TREATMENT

Timber felling started in September 1977 and was completed in December 1979. In all, 2103 circular clearings (737, 20 m dia., 0.031 ha; 1366, 15 m dia., 0.018 ha) were created. Two sizes were used to maintain opening diameter between 3/4 and 1 1/2 H. The layout was purely mechanical over most of the watershed, the clearings centered on alternate intersections of a square grid network of lines 20 m or 15 m apart. In the few instances where a natural opening was encountered, the centre of the clearing to be created was shifted to coincide with it. Slash and non merchantable inaccessible trees were flattened. Merchantable trees were removed in tree lengths with rubber tired skidders from the more accessible portions of the watershed during 1980 and 1981. Skid trails to remove these trees created some additional clearcut area that has yet to be included in the total area treated. The treatment cost of approximately CAN\$2500 per hectare was entirely underwritten by the member agencies of the Alberta Watershed Research Program.

### EVALUATION

#### Snow accumulation

Snow accumulation has been estimated from depth-density measurements at each point on a grid network for all of Marmot since 1969 (Golding 1972). The snow water equivalent present on Twin can be estimated from similar data on Middle. Surveys during March 1980 to 1982 indicate no increase in total snow accumulation as a result of the treatment, but 128% more snow is in the clearings than under the intermixed forest, Table 2. These findings agree well with our results from the design study (Golding and Swanson 1978) and those of Hoover and Leaf (1967). We have not examined ablation rates in these clearings but this is planned for future years.

Table 2. Snow accumulation on Marmot, Twin sub basin, 1980 - 1982.

	Basin		Treatment		Difference	Percent
	Actual	Predicted	Clearings	Forest		
1980	261 mm	253 mm	281 mm	218 mm	63 mm	129 %
1981	169	163	195	146	49	133
1982	190	189	208	169	39	123
			3-year mean		50 mm	128%

#### Water yield

Water yield has increased slightly for the two years of record, Table 3. We anticipate greater increases in subsequent years as Cabin sub basin, which was clearcut in 1974, did not produce measureable increases until 1977, some two years after treatment. We do not have sufficient data at this time to evaluate the effect of this honeycomb treatment on recession flows.

Table 3. Marmot Creek watershed, Twin sub basin streamflow data 1980 - 1981.

Year	Annual Water Yield			
	Actual	Predicted	Difference	Percent
1980	506 mm	542 mm	36 mm	107%
1981	617	633	16	103

#### SUMMARY

The forested portion of Twin subbasin of the Marmot Creek Experimental Watershed in Alberta, Canada, was harvested in a honeycomb pattern of 1-tree height diameter circular clearings during 1977-1979. Our goal for this treatment was to alter hydrograph shape in favour of late season streamflow. Our research on plot studies elsewhere indicated that at peak snowpack, this size clearing would contain 38 percent more snow than under uncut forest and that it would ablate 24 percent slower than either that under uncut forest or that accumulated in clearcuts larger than 3 to 5 tree heights across. These snow research findings suggested that the water yield from a catchment harvested in such tiny clearings might occur later in the water year -- a quite different time distribution than has been reported from harvests consisting of larger size clearcuts.

For the first three years since treatment, 28 percent (50 mm) more snow water equivalent accumulated in the clearings than under adjacent treed patches. There has been no increase in total snowpack on the treated catchment. Annual water yield increased by 36 mm in 1980, 16 mm in 1981. There are insufficient data at this time to evaluate the effect on recession flow.

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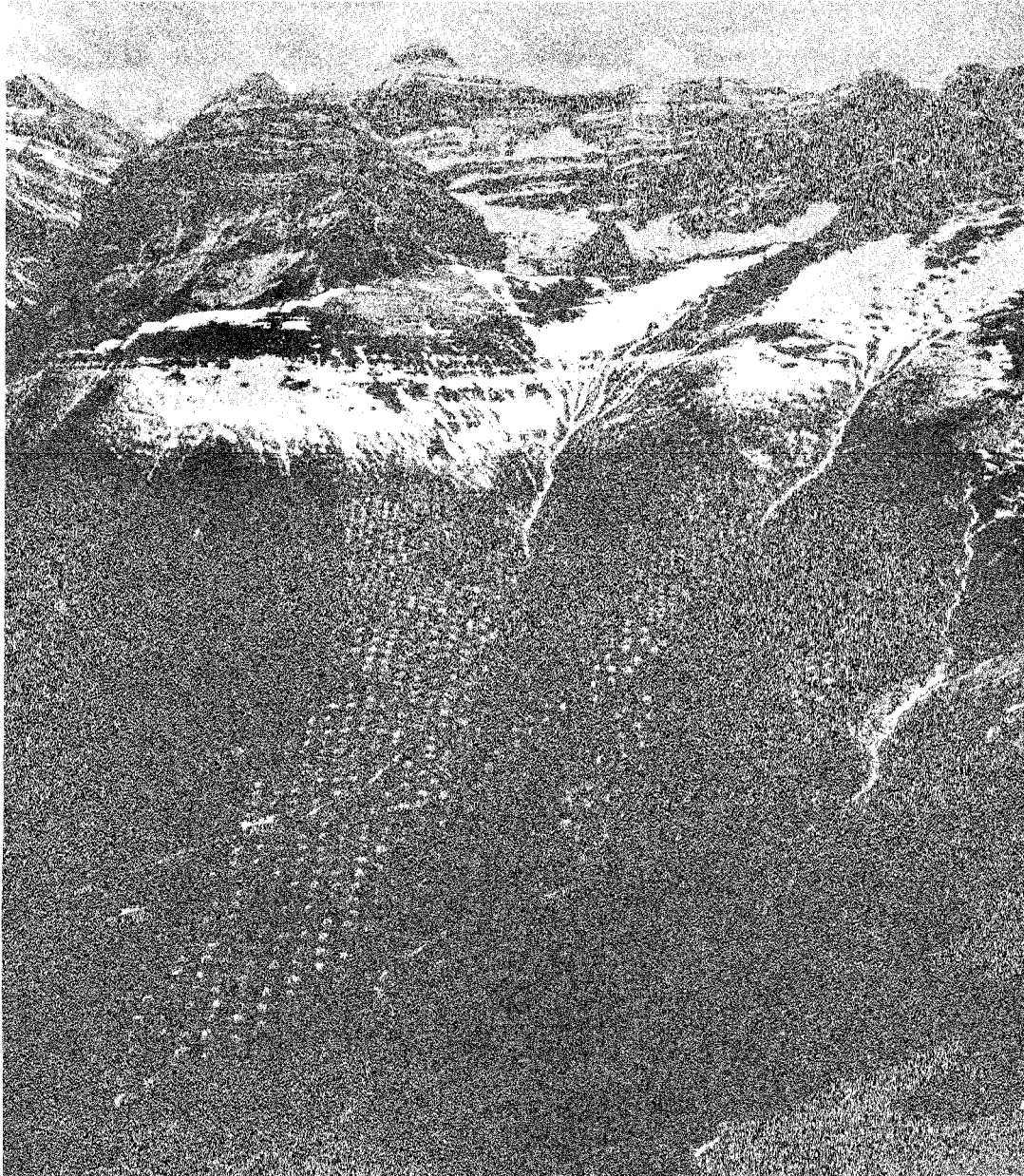


Figure 1. The "honeycomb forest". Marmot Creek Experimental Watershed, Alberta, Canada.