PRELIMINARY INVESTIGATION OF SNOW

ACCUMULATION AND MELTING IN FORESTED AND

CUT-OVER AREAS OF THE CROWSNEST FOREST

By

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## Introduction

In 1962, the Marmot Creek Experimental Watershed was set up in the Kananaskis Valley, some 50 miles west of Calgary, Alberta. The site is located on the eastern slopes of the Rocky Mountains. Jeffrey, 1964 1/

This watershed was established in an area covered predominantly by spruce-fir forest with the ultimate objective of assessing the effect of vegetation changes on water yield, quality and regimen.

Early in the calibration period for the experimental area a number of plot studies were instituted. These were designed to provide qualitative guidelines for the final manipulative processes.

In the case of plot studies involving snow accumulation and melting the necessary cutting of trees precluded the use of Marmot Creek Basin itself. The Crowsnest Forest in south-western Alberta was selected for study. This region provided areas of comparable cover, together with ease of access and a number of pre-cut blocks, suitable for this preliminary investigation.

## Objectives

The primary objective of this study was to establish the pattern of snow accumulation and melting in adjacent cut-over and uncut areas on several aspects.

Further objectives involved comparisons of snow accumulation and melting in a shelterwood cut and a contiguous uncut area as well as between similar northerly aspects at different elevations. Work has been started in the 1966 season to determine deposition patterns in cut-over areas.

It should be noted that in taking advantage of existing unstandardized cutting patterns it was inevitable that certain factors of slope, aspect, and curvature would exert a modifying influence on the basic changes attributable to the cutting patterns. However, it was judged that these would be small relative to the vegetation influence.

It is hoped that results from these studies, combined with similar work elsewhere, will provide guidelines for setting out more intensive designed cuts in the Crowsnest Forest and eventually assist in prescribing cutting patterns for the Marmot Creek Basin.

## Methods

A total of five pairs of snow courses were set up in the fall of 1964. One member of each pair was established on a cut-over, or shelterwood cut area, while the other was located in adjacent standing forest.

Each course was set out in the form of a cross with ten points ranging up and down the slope, and a further ten running across. A Mount Rose snow sampler was used for all measurements. Readings were started in January and continued on a monthly basis until April when two readings were taken. Thereafter weekly sampling was adopted until the end of snow melt.

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Snow markers used on these courses were 8 foot by 2 x 1 inch lath attached by wire to driven 4 foot by 2 x 2 inch pegs.

The aspects sampled by the courses were north, south and east with the north - facing course duplicated to provide an altitude comparison.

With the exception of the courses on the shelterwood cut at 5,000 feet m.s.l. the remainder were located between 5,500 and 6,050 feet m.s.l.

Cut over areas ranged in size from 9.7 acres to 15.5 acres with widths varying from 8 to 16 times the surrounding tree height. Tree height in all stands averaged approximately 80 feet.

In the shelterwood cut approximately 30 per cent of standing volume over eight inches D.B.H. was removed from a five-acre block originally containing in excess of 350 M. bd. ft. per acre.

## Results

### Snow Accumulation and Melting

On the basis of data collected during the winter and spring of 1965, it was found that in all cases clear-cut areas accumulated more snow than the adjacent, undisturbed forest. These differences ranged from a minimum of 6.5 inches to a maximum of 22.5 inches. The shelterwood cut accumulated only 1.5 inches more than its associated uncut area. (See Table 1.)

TABLE 1

MAXIMUM SNOW ACCUMULATION (inches)

(Recorded March 25,1965)

| Course & Aspect | Cut | Uncut | Difference | % Increase |
|---|---|---|---|---|
| 1. Southerly | 65.5 | 54.0 | 11.5 | 21.5 |
| 2. Northerly * | 71.0 | 64.5 | 6.5 | 10.0 |
| 3. Northerly | 58.0 | 50.5 | 7.5 | 14.6 |
| 4. Easterly | 71.0 | 48.5 | 22.5 | 46.4 |
| 5. Easterly + | 52.5 | 51.0 | 1.5 | 3.0 |

* High elevation course + Shelterwood course

Anderson (1963), 2/ notes that at the Central Sierra Snow Laboratory long-term average increases in snow accumulation on clear-cut blocks were 12 inches greater than in the surrounding forest. Clear-cut blocks were defined as cutting blocks of more than 20 acres in area or strips wider than four times tree height. On the basis of the latter definition the areas in the Crowsnest Forest would be comparable. The average of one season's records from the cut-over areas in the Crowsnest Forest indicates close agreement with Anderson's figures.

The melting of snow in the cut-over blocks and in the shelterwood cut was more rapid than in the forest. (See Table 2) For the period March 25 to June 3 melting in the cut-over areas exceeded that in the forest by a range of 12 to 23 inches. During the period March 25 to May 27, 13 inches more melt occurred in the shelterwood cut than in the undisturbed forest. This pattern of more rapid melt in open areas is also in general agreement with Anderson's findings.

TABLE 2

SNOW MELT-RATE COMPARISONS (inches of snow)

| Course & Aspect | Melting Period | Cut | Uncut | Difference |
|---|---|---|---|---|
| 1. Southerly | Mar. 25 - June 3 | 66.0 | 52.0 | 14.0 |
| 2. Northerly * | Mar. 25 - June 3 | 56.5 | 43.5 | 13.0 |
| 3. Northerly | Mar. 25 - June 3 | 57.0 | 45.0 | 12.0 |
| 4. Easterly | Mar. 25 - June 3 | 69.0 | 46.0 | 23.0 |
| 5. Easterly + | Mar. 25 - May 27 | 54.0 | 41.0 | 13.0 |

* High elevation course + Shelterwood cut

In spite of the greater accumulation of snow in the cut-over areas the relatively faster melt rate resulted in their being clear of snow slightly in advance of the surround forest.

Assuming course No. 2 was clear by June 30 the delay between associated cut and uncut areas in becoming completely free of snow, was within a two-week period. (See Table 3)

At the latest date allowing a comparison to be made between cut and uncut areas the difference in average snow depth and water equivalent to the nearest half-inch ranged from 1.0 to 4.0 inches and 0.5 to 1.5 inches respectively.

TABLE 3

POINTS RECORDING SNOW (out of 20)

| Course | May 13 | May 19 | May 27 | June 3 | June 9 | June 16 |
|---|---|---|---|---|---|---|
| 1 cut | | | 9 | 2 | Clear | |
| 1 uncut | | | 20 | 8 | Clear | |
| 2 cut | | | | 19 | 14 | 2 * |
| 2 uncut | | | | 20 | 19 | 11 * |
| 3 cut | | | 19 | 3 | Clear | |
| 3 uncut | | | 20 | 13 | 10 | Clear |
| 4 cut | | | | 7 | Clear | |
| 4 uncut | | | | 14 | 5 | Clear |
| 5 cut | 15 | 2 | 1 | Clear | | |
| 5 uncut | 20 | 20 | 20 | 4 | Clear | |

* It was assumed these were clear at latest by June 30.

Maximum Water Equivalent

It was observed that with one exception maximum water equivalent was obtained approximately one month later than maximum snow accumulation.

TABLE 4

MAXIMUM WATER EQUIVALENT (inches)

| Course & Date | Cut | Uncut | Difference | % Increase |
|---|---|---|---|---|
| 1 March 25 | 21.0 | 16.0 | 5.0 | 31.2 |
| 2 April 22 | 26.0 | 24.5 | 1.5 | 6.1 |
| 3 April 22 | 17.5 | 16.0 | 1.5 | 9.3 |
| 4 April 22 | 25.5 | 15.5 | 10.5 | 64.5 |
| 5 April 22 | 16.5 | 15.0 | 1.5 | 10.0 |

Rothacher 1965, 3/ reported a similar situation obtaining for two-chain-wide strips cut in a uniform mountain hemlock - true fir forest near Willamette Pass, Oregon. Packer 1962 4/ reporting on four years of record for some 1200 sampling points in western white pine forests of Northern Idaho, noted that with few exceptions maximum snow depth coincided with maximum water equivalent.

Differences in Water Equivalent in Relation to Altitude

A comparison was made between the two north facing courses (No. 2 and No. 3) within the forest. The difference in elevation was approximately 550 feet. The difference in maximum water equivalent recorded was 8.5 inches. This amounts to 1.5 inches additional water equivalent for each rise of 100 feet. Results from the Upper Columbia and Central Sierra Snow Laboratories 1956 5/ have indicated rises ranging from 1 to 2.5 inches per 100 foot increase in elevation.

Pattern of Snow Accumulation in Cut-Over Areas

During March 1966, a profile was taken across the cut-over strips on courses 1 to 4 in an attempt to detect any pattern of deposition. In each case there was an increase in deposition towards the centre of the cleared area.

This accumulation was more marked on the north and south facing slopes than in the case of the east-facing slope. On both north-facing cut-over blocks (Fig. 1), there was a noticeable accumulation of snow at, or very close to, tree line on either side. This was followed by a sudden depression of the pack prior to the main build up again towards the centre of the cleared area. This tendency was exhibited only on the north side of the east-facing block. There was little evidence of a similar pattern on the south-facing slope due possibly to the presence of gullies immediately adjacent to the forest at the east and west ends of the block.

On the high-elevation, north-facing course the peak water equivalent at the trees on the windward side of the strip, exceeded that at the centre by 16.5 inches. It is believed that this was caused by stronger winds at this particular elevation. Evidence to support this is provided by the relative blow-down rates of snow markers on the two courses. Over the same period 60 per cent of stakes were lost on the high elevation course versus 10 per cent on the other.

Anderson & Gleason 1959, 6/ reporting on water content of a snow pack in a natural opening, one and one-half times tree height in width, recorded depressions just within the trees on both the leeward and windward side of the opening. They do not however, record a similar depression within the cut-over area. Goodell 1956 7/ reporting on snow accumulation in small openings up to 60 feet in diameter with tree heights averaging 80 feet, notes an increase of about 0.07 inches water equivalent for each foot of horizontal distance measuring from the edge of the canopy towards the centre of the opening. This also would indicate a lack of depression in the snow pack within the open area.

Further profiles are planned during April 1966, to provide more detailed information on the pattern of deposition in the cut-over area.

## Conclusions

On the cut-over areas of the Crowsnest Forest preliminary work suggests that there is a greater accumulation of snow than in the surrounding forest.

The melting pattern indicates that this greater accumulation melts slightly in advance of the snow within the forest. With these conditions obtaining it seems reasonable to anticipate a somewhat earlier and higher runoff. Cutting patterns of this type while allowing a higher yield do not provide for an effective extension of runoff later into the season.

Results from the shelterwood study indicate a more rapid melt at this altitude and suggest the need for further comparisons with cut-over areas with the same elevation and aspect.

On the basis of comparison between two north-facing courses it would seem that increases in water equivalent with elevation are within a range established elsewhere.

The pattern of accumulation within cut-over areas requires further study with emphasis on wind measurement and grid sampling. Preliminary work suggests the possibility of different deposition patterns existing in relatively large open areas of approximately eight times tree height in width when compared with others of one and one-half height or less.

Finally, planning for future cutting experiments will require careful selection of areas taking into account such factors as slope aspect and curvature which exert independent influences on accumulation and melting processes.

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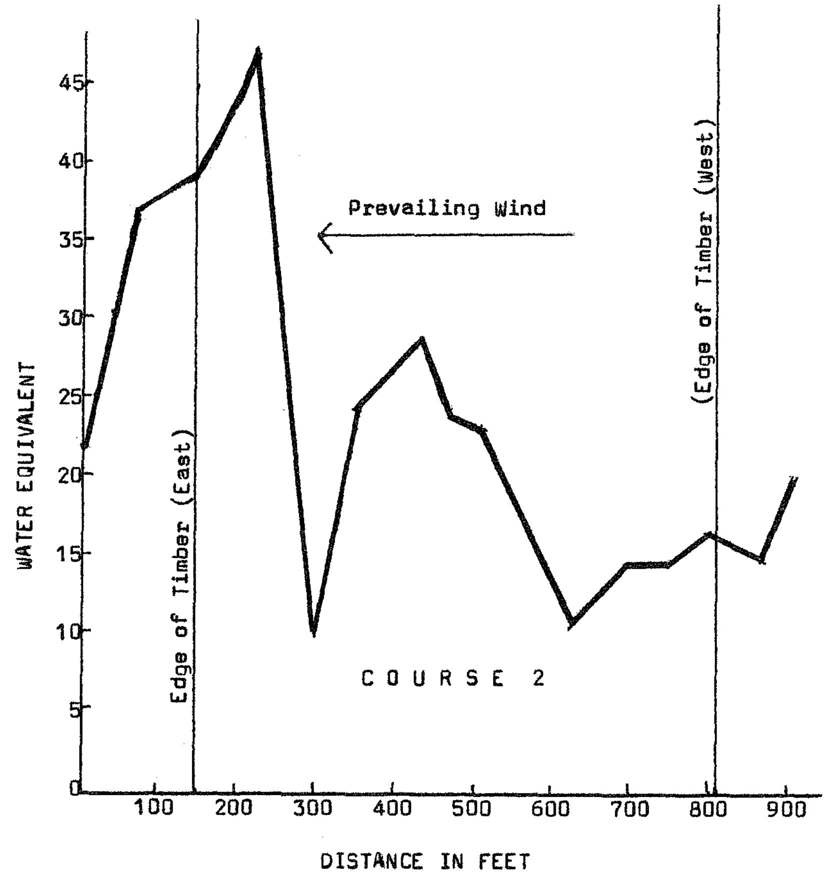
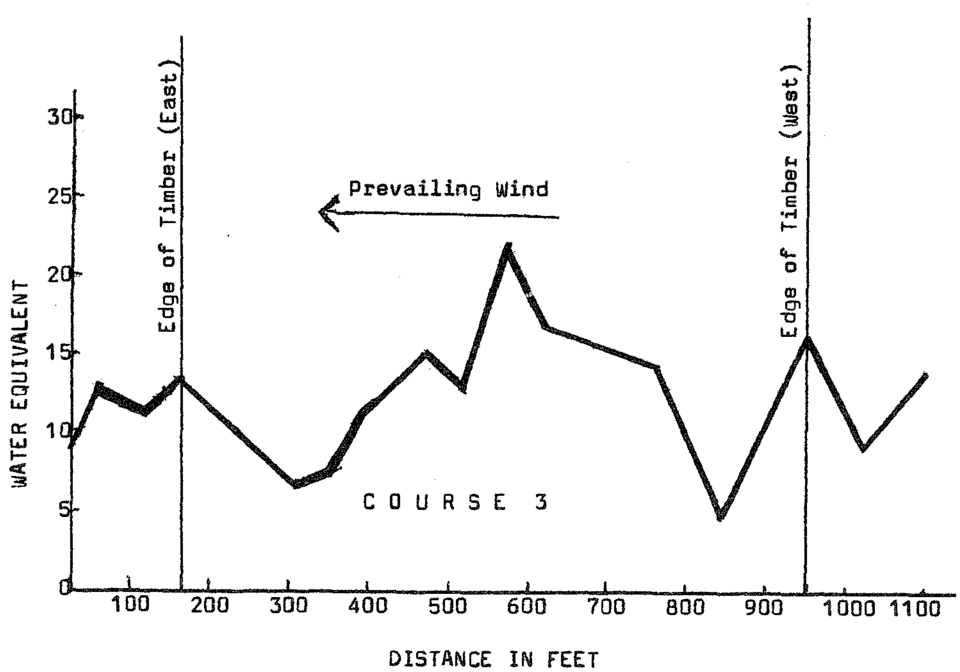

45
40
35
30
25
20
15
10
5
0
WATER EQUIVALENT
Edge of Timber (East)
Prevailing Wind
(Edge of Timber (West)
COURSE 2
100
200
300
400
500
600
700
800
900
DISTANCE IN FEET


30
25
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15
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5
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WATER EQUIVALENT
Edge of Timber (East)
Prevailing Wind
Edge of Timber (West)
COURSE 3
100
200
300
400
500
600
700
800
900
1000
1100
DISTANCE IN FEET

Figure 1