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Snow Distribution on Forest Clearcuts in the Swedish Mountains

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The paper is focused on the problem of choosing observation localities at the margin of forests for snow surveys. A systematic study was made of differences in snow depth and water equivalents of snow accumulation near the boundaries between forests and open land. The field data were collected during the winter seasons 1983-84 and 1984-85.

The study involves sounding snow depths and calculating water equivalents of the snow cover from profiles crossing distinct boundaries between forests and clearcuts. The snow accumulation was found to be relatively large in a zone up to 40 m just outside the forest boundary. The accumulation up to 15 m just inside the forest boundary was relatively small as compared to the forest in general.

A slight excess of snow in the forest compared to the clearcuts, established at the beginning of the snow accumulation season, gradually turns into a small deficit in April. During most of the melting season the amount of snow in the forest is considerably bigger than in the clearcuts.

Introduction

The possibility to predict run-off from catchment areas is vital for an optimal management of hydroelectrical power plants. In order to make a reliable run-off forecast it is important to estimate the amount of snow in a drainage basin. It is well known that the snow distribution is uneven in mountain regions, where hard winds frequently redistribute the snow (e.g. WMO 1972). The problems encountered when snow distribution is to be determined in forest areas is less discussed. However, some studies are published (e.g. Perälä 1971). It is also well known that snow depth in forests could be quite different from that on open fields in the same general area (e.g. Perälå 1971). The snow depth is most frequently determined only along a small number of profiles where the proportions of forest to open fields are not considered. Small errors in the field data can lead to large errors in run-off prediction.

Field Data

Localities with a distinct border between forest and open clearcuts were desirable for this study. Mostly, the boundaries are relatively indistinct because of trees or bushes left over in the clearcuts. Three good localities were selected for this study, here referred to as Lossen, Sörsmolet and Grundsjön (Fig. 1). Lossen is located on a gentle slope (5° towards NE) at an altitude of 600 to 660 m. The surrounding forest consists of spruce and pine. Near the maximum altitude the forest is sparse. At Sörsmolet, which is located between 670 and 700 m altitude, the spruce and pine forest is relatively open. The area slopes only about 3° (towards the east). The third locality, referred to as Grunsjön, is located on a northfacing slope (5°) between 660 and 680 m altitude. Also here, the spruce forest is relatively open.

Methods

Snow depth was measured by a steel probe with an accuracy of ± 1 cm. On some measuring points it was necessary to dig pits to assure that the probe had reached the ground and not an ice crust. The snow pack was measured every 20 m along profiles. The distance between the measuring points was estimated by »step counting«.

Snow density was determined by weighing, with a spring balance, known volumes of snow from different parts of the clearcut, alternatively the forest, at 50-60 points. Vertical samples were taken by a Swedish snow sampler (38 mm diameter). A correction was made for the error caused by this sampler, as it gives a value that is 7 per cent too high (Persson 1971). On some measuring points, pits were dug to assure that the sample comprised the whole snowpack. All density measurements at each locality were taken in the course of one single day. Curves showing increase in density with increasing snow depth were drawn. The water equivalent of snow at each point was then taken from the density curves.

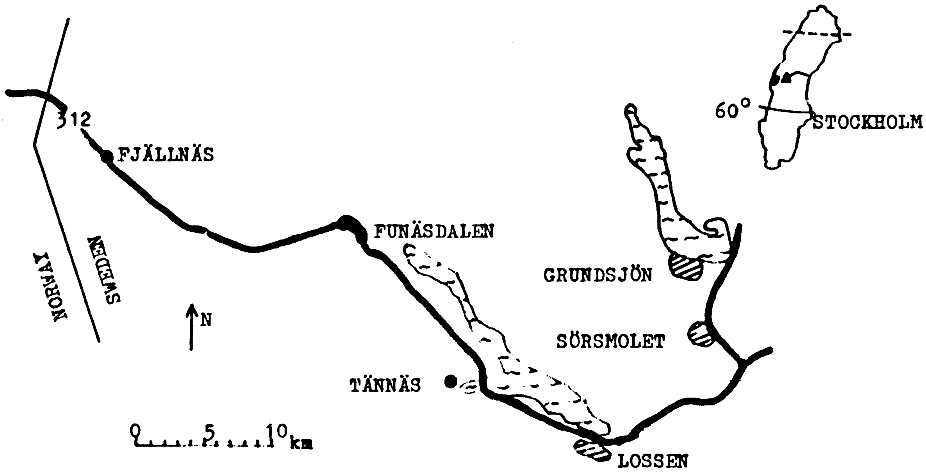

Fig. 1. Location map and map of northwestern part of the province of Härjedalen with the three clearcuts investigated.

Both winters, the first four snow surveys were made during the snow accumulation season while the last one was made one or two weeks after melting had started. During some of the surveys, relatively large amounts of snow were resting on tree branches, giving a slightly smaller surveying result.

The profiles were laid out at right angles to the selected, distinct border-lines. There were no single trees or bushes at any of the clearcuts. Snow depths were measured at 10 m intervals along the profiles. On the clearcuts, the sounding points were situated about 45, 35, 25, 15 and 5 m from the border-line, in the forest they were about 5, 15, 25, 35 and 45 m from the border-line.

The profiles were surveyed for the first time in mid December, whereas the last survey was made in early April.

During both winter seasons the border-line was situated east of the clearcut at »Lossen«, but to the west at the other clearcuts. In the winter of 1984-85 another similar border-line at »Grundsjön« was added to the study. Here the clearcut was situated to the east of the forest.

Results

Snow density was equal on clearcuts and in the surrounding forests during surveys made before April. In early and late April 1984, however, snow density in the forest was between 4 and 6 per cent lower than on the clearcuts. The corresponding values for 1985 were 4 to 5 per cent. This difference in the latter part of the season

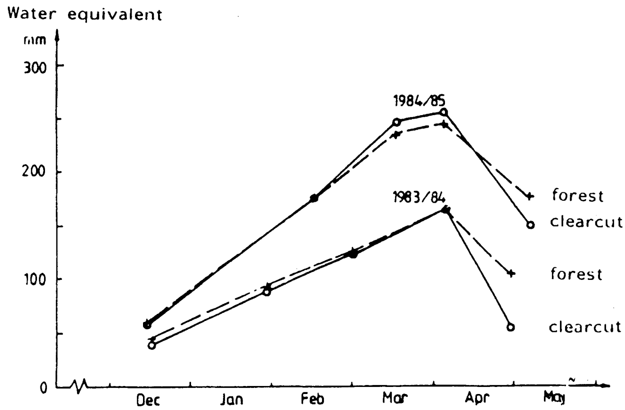

Fig. 2. Water equivalent of snow on clearcuts and in surrounding forests, part of NW Härjedalen, winters 1983-84 and 1984-85. Difference in snow pack between the clearcuts was considerable at the end of April.

is probably due to increased incoming radiation outside the forest.

Fig. 2 shows the water equivalent of snow on the clearcuts and in the surrounding forests during the winters of 1983-84 and 1984-85. The snow accumulation normally starts earlier in the forest than in the clearcuts. The relative difference in total snow accumulation between clearcuts and forest is almost constant until the end of February. Snow on the trees will eventually fall to the ground during that period. But towards the end of the accumulation season, some of the snow on the trees will melt or evaporate. On some measuring occasions, there was a maximum of estimated 2 mm of snow in water equivalent on the branches (a subjective estimate made by three hydrologists).

Fig. 3 shows the excess or deficit of snow on the clearcuts compared to the forests in the Lossen, Sörsmolet and Grundsjön study areas during the winter seasons of 1983-84 and 1984-85.

The water equivalent was calculated on 27 profiles at four surveys during the winter 1983-84. The sounding points were places 45, 35, 25 etc. m away from the border-line on every profile. For each survey point, the water equivalent was divided by the mean of the water equivalent on the clearcut or for the forest respectively. For all points 45 m away from the border-line, the mean of that ratio was calculated; so were the means for all other points at fixed distances from the border-line. The significance on the levels of 95, 99 and 99, 9 per cent was then tested for every point; the results are given in Table 1.

During the winter 1984-85, on four surveys, 11 of the above mentioned profiles were used, together with 5 new ones from another part of the clearcut at Grundsjön.

Fig. 4 shows that results from the two winters are fairly similar. A surplus of

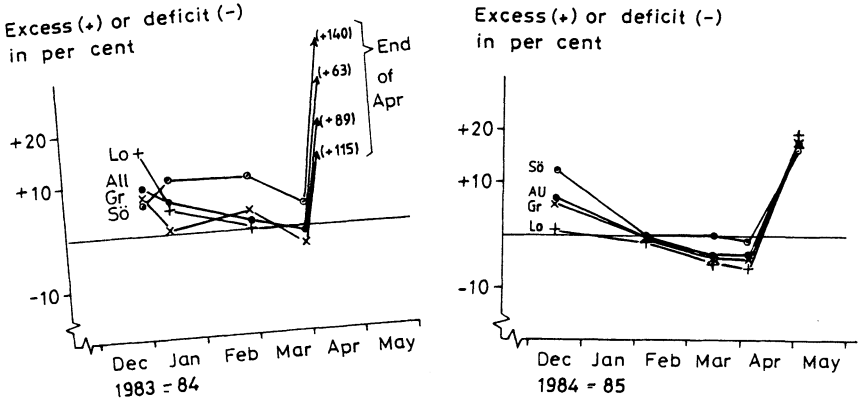

Fig. 3. Excess of snow (+)/deficit of snow(-) given as per cent for the forest compared to the clearcuts for investigation areas Lossen (Lo), Sörsmolet (Sö) and Grundsjön (Gr), and all put together (All), NW Härjedalen, winters 1983-84 and 1984-85.

snow is found within 35 m from the border-line in the clearcut area, with a definite increase closer to the border-line. The snow depth decreases significantly a few m into the forest. The effect of the clearcut could be easily seen at a distance of 15 m (in 1983-84) and 25 m (in 1984-85) into the forest. The significance on the 95 per cent level for points 45 m away in the forest is purely incidental, since the effect of the clearcut could not be traced longer than about 35 m into the forest.

No melting snow had been observed during any one of the snow surveys. Curves in Fig. 4 appear to be about the same on every single measuring occasion and for all clearcuts, regardless whether the clearcut is situated east or west of the forest; i.e. apparently regardless of predominant winds.

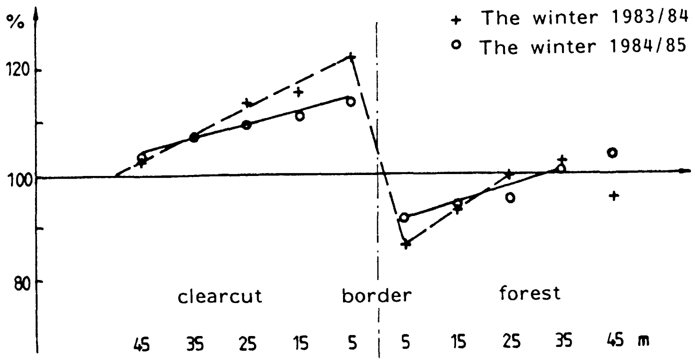

Fig. 4. Water equivalent of snow pack at various distances from the border-line between clearcuts and forests, given as per cent of means for the two types of terrain. Winters 1983-84 and 1984-85.

Table 1 – Water equivalent of snow pack at different distances from the border-line between clearcuts and forests. The significance for the deviation from the means on the clearcuts and at the forest points is shown. Winters 1983-84 and 1984-85.

			clearcut					forest				
m from border-line			45	35	25	15	5	5	15	25	35	45
	$\bar{x}$	1983-84	1.027	1.063	1.135	1.156	1.220	0.869	0.931	0.994	1.023	0.952
	$\bar{x}$	1984-85	1.0357	1.0699	1.0947	1.1083	1.1338	0.9170	0.9313	0.9524	1.0052	1.0361
level of significance in per cent	95	1983-84	no	yes	yes	yes	yes	yes	yes	no	no	yes
		1984-85	no	yes	yes	yes	yes	yes	yes	yes	no	yes
	99	1983-84	no	no	yes	yes	yes	yes	yes	no	no	no
		1984-85	no	yes	yes	yes	yes	yes	yes	yes	no	no
	99.9	1983-84	no	no	yes	yes	yes	yes	no	no	no	no
		1984-85	no	no	yes	yes	yes	yes	no	no	no	no

Conclusions

The total water equivalent of the snow pack on clearcuts and in surrounding forests was calculated for one winter rather poor in precipitation and one rather rich. Until mid February or early March, the snow accumulation increases rather uniformly in both kinds of terrain, as can be seen in Fig. 2. The conformity is even larger than the curves suggest, because some millimeters of water must be added due to snow still resting on the trees. Later in the season, the snow accumulation in the forest decreases in relation to that on the clearcuts, probably because the snow on the branches partly melts or evaporates instead of adding to the snow pack. Finally, melting is much quicker on the clearcuts than in the forest when the spring thaw begins.

Border-lines between clearcuts and forests seem to act like snow traps. The amount of snow is larger on clearcuts up to at least 35 m from the forest. The snow pack increases almost in a linear way towards the border-line. A few meters into the forest, the snow pack suddenly decreases for about 15 meters. This is probably due to wind conditions at the border-line. Isolated snow surveys in power-line clearings, along roads and other quite thin 'lines' in the landscape, will thus give non-representative values of the water equivalent of the snow cover in larger areas.

For the benefit of downhill skiers, many narrow clearcuts will increase snow accumulation in comparison with few and wide ones.

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