THE INFLUENCE OF SNOW ON THE INPUT AND MOVEMENT OF CATIONS WITHIN A SMALL WATERSHED: METHODS AND PRELIMINARY RESULTS

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A large amount of research concerning the functioning of biogeochemical cycles has been carried out in small watersheds (e.g. Likens et al. 1967), but little attention has been placed on examining the importance of the snowpack as a direct source of nutrients to a watershed and its role in the export of nutrients from a watershed. Recently, however, studies have begun to examine the chemical importance of the snowpack especially in relation to acidic precipitation (Johannessen and Henriksen 1978, Skartveit and Gjessing 1979). As part of a detailed investigation of the flux of major cations within a small watershed (47.5 ha) near Peterborough in south-central Ontario (Pierson in prep.), we have examined the snowpack in an attempt to quantify its importance as a source of nutrients. The stream draining this swampy watershed flows only a few months each year, and the spring snowmelt period is particularly important from the viewpoint of both hydrological and nutrient budgets.

A peak snow survey in which samples were collected from open field and wooded areas (fig. 1) and a t-test have shown that the vegetation overlying the snowpack can cause significant variations in its Ca^{++}, Mg^{++} and Na^{+} concentrations. The higher concentrations found in the wooded areas are probably due to the removal of cations from vegetation by snow, or the direct incorporation of vegetation into the snowpack. Three Sacramento snow gauges were placed in the watershed (Fig. 1), gauge 1 in an open field, gauge 2 in a clearing surrounded by deciduous trees, and gauge 3 in a heavily wooded coniferous forest. Figure 2 shows a large difference in the total mean cation concentration measured for the three gauges (analysis of variance shows a significant difference in Ca^{++}, Mg^{++} and Na^{+} concentrations). The majority of this difference seems to occur between gauge 2 and gauges 1 and 3 and can be attributed to two sources of cations. Gauge 1 has a high cation concentration due to inorganic particulate matter since in the field area there are higher wind velocities and a greater amount of exposed soils. Gauge 3 has a high concentration due to the influence of overlying vegetation. Gauge 2 has the lowest concentration since the input of cations from both of these sources is minimized. Figure 2 also shows the snowcourse samples to be of a higher cation concentration than the weighted mean snow gauge concentrations. Spatial variations in the deposition of particulate matter (the three gauges may not be representative) and changes in the cation content of the snowpack over time probably explain this. Particulate matter in the snow pack will have had a greater amount of time to act on the snow by either contributing cations to it, or by neutralizing hydrogen ions within it, compared with the snow gauges which were emptied on a weekly basis. Freeze-thaw episodes, and leaching by rain would tend to augment the effects of particulate matter. Also the effects of sublimation would be expected to increase the cation concentration in the snowpack over time.

The snowpack had a total cation concentration of 1.85 kg/ha which accounted for 82% of the cation input to the watershed during the entire spring snowmelt period (March 20th to April 9th, 1980), and also accounted for 46% of the water input to the watershed over this time. Thus far we have only analyzed data for the peak snowmelt period from March 20th to 22nd (Fig. 3). At this time a large percentage of the snowpack melted and 49.5 mm. of rain also entered the watershed. Discharge was measured, and chemical samples collected from the two weirs shown in Figure 1. There was a net cation export of 4.09 Kg/ha from the watershed during this period and the snowpack could have accounted for a maximum of 45%

of this. Calculations show, however, that only 26% of the water contained in the snowpack and entering the watershed as rain left the watershed during these three days. The direct contribution of cations from the snowpack to the watershed output during this time is, therefore, almost certainly over-estimated. (Note: The remaining cations from the snowpack probably were exported later in the spring runoff period). As a rough estimate of the input of cations to the watershed from the snowpack during peak runoff, rain and snow cation concentrations in Table 1 were multiplied by 0.26. The fact that cations are commonly lost from the snowpack at a rate disproportionate to the rate of melting (Johannessen and Henriksen, 1978) may partially invalidate this assumption: however, we feel that on a mass balance basis this assumption is reasonably accurate for determining total cation concentrations. Transformation of the data in this manner indicates that the snowpack accounted for 12% of the cations exported from the watershed between March 20th and 22nd.

Although the direct input of cations from the snowpack does not have a major effect on the watershed's nutrient budget during peak runoff, the water released from the snowpack significantly increases the export of nutrients already present in the watershed. Since the stream flows only for short periods during the year, particularly in the spring and occasionally in the fall, cations accumulate within the watershed during most of the year and are flushed out early in the spring melt period. Both our data and that of Wolfe (1980) have shown nutrient export to be strongly related to stream discharge. Thus it can be assumed that melt water leaving the watershed is mainly transporting cations obtained from terrestrial sources within it.

References

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TABLE 1. Cation budget for the peak runoff period (March 20-22, 1980).

	Input (rain) Kg/ha	Input (snow) Kg/ha	Output (stream) Kg/ha
Ca^{++}	1.11×10^{-1}	1.43	3.08
Mg^{++}	8.47×10^{-3}	9.8×10^{-2}	3.20×10^{-1}
Na^{+}	4.78×10^{-2}	1.96×10^{-2}	1.57×10^{-1}
K^{+}	1.44×10^{-2}	2.99×10^{-1}	5.27×10^{-1}
H^{+}	2.38×10^{-2}	4.19×10^{-3}	1.28×10^{-4}
Total	2.05×10^{-1}	1.85	4.09

Fig. 1 TELFORD WATERSHED

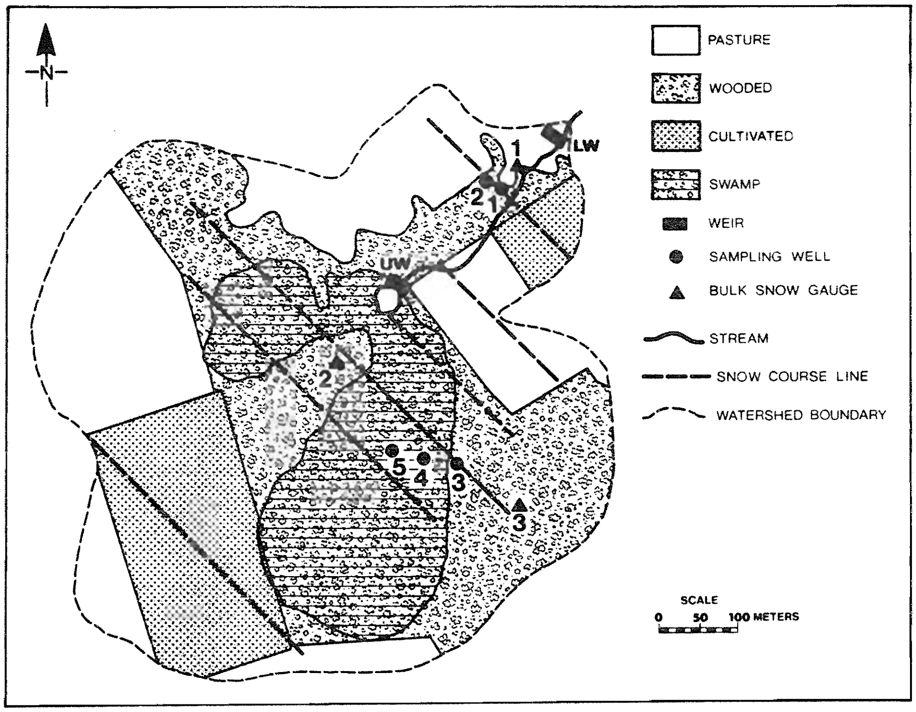

Fig. 2 TOTAL MEAN CATION CONCENTRATION FOR SNOW GAUGES AND SNOW COURSE SAMPLES

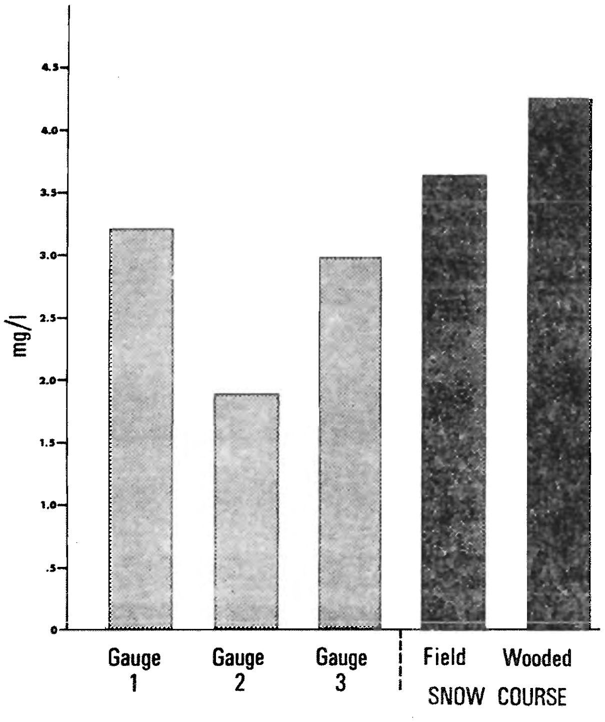

Fig. 3 DISCHARGE, CATION CONCENTRATIONS AND pH DURING PEAK RUNOFF