Relationships Between Point Snow Depth Measurements and Snow Distribution at the Landscape Level in the Southern Boreal Forest of Saskatchewan

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EXTENDED ABSTRACT

Canada's snow depth observing network is comprised of point observations made from manual ruler measurements or automated sonic ranging instruments. Manual measurements are often made once per day or every six hours, depending on the station, while automated sensors are often used to record snow depth continuously. The distribution of snow in a landscape is a result of microclimatic, topographic and vegetative effects on snow accumulation, redistribution and ablation. Given this potentially high degree of variability, the efficacy of fixed point depth observations in representing a mean snow depth for a landscape needs to be addressed (Schmidlin, 1989, 1990; Brown and Goodison, 1993, 1996). In this study, data from nine Boreal Ecosystem Research and Monitoring Sites (BERMS) in northern Saskatchewan were used to assess the relationships between landscape scale snow depth variability, ascertained from snow survey transects, and automated point measurements (Campbell Scientific model SR50) for the 2002–03 accumulation season.

The nine research sites in the BERMS network represent a wide range of forested, open and disturbed landscapes. Two mature sites (~100 years old) represent wet (black spruce, OBS) and dry (jack pine, OJP) coniferous environments, while a mature aspen (OA) stand represents a deciduous forest. Two mixed-wood sites are regenerating following fires in 1989 (F89) and 1998 (F98), while three dry conifer sites are regenerating following timber harvesting in 1975 (H75), 1994 (H94) and 2002 (H02). A patterned fen (FEN) is the final site in the network, representing open wetland areas in the boreal forest. At the mature jack pine and aspen sites, two SR50s were installed to monitor changes in snow depth in clearings and under the canopy, and single sensors were installed at the remaining sites. Measurements were output every 30 minutes, and these data were used to determine a daily median snow depth. Monthly snow surveys were performed at all BERMS sites along fixed transects 100m long. Five snow water equivalent (SWE) measurements were made at stakes (20m spacing) along the transect, with ten depth samples taken between stakes for a total of 45 depth samples.

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Survey results from winter 2002–03 indicated greater snow accumulation at the FEN, H75, H94 and F98, and lowest accumulation at the recent clearcut H02. The individual snow surveys showed a wide range of depths at each site, with increasing variability over time to the period of peak accumulation (Figure 1). Comparing the daily median depth from the SR50 data showed that the fixed point measures of snow depth did not statistically represent the average surveyed depth (with the exception of the two fire sites F98 and F89), even for relatively uniform snow covers. The fixed point measurements consistently over- or under-represented the areal average.

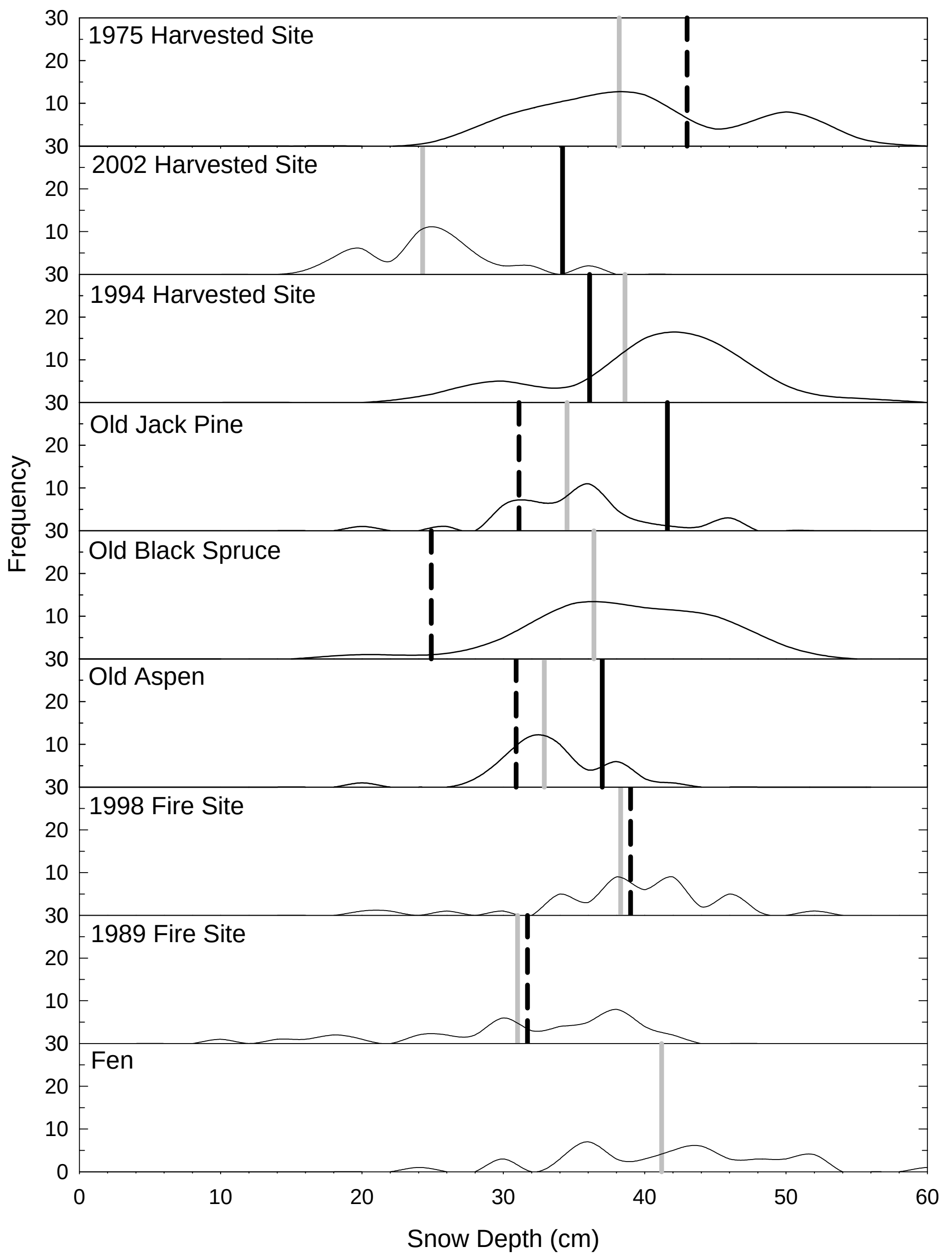

Figure 1. Binned snow depth frequency histograms for mid-March 2003 snow surveys. The black vertical lines mark the daily median depth from the SR50 measurements in clearings (solid) and subcanopy (dashed), and the survey means are marked in grey. SR50 data from the fen site were unavailable.

Simple, strong linear relationships were found between the fixed point daily median values and the snow survey, or landscape, mean depths for the accumulation season (Figure 2). These relationships can be used as "scaling factors" to allow improved interpretation of the fixed-point measurements for modelling exercises and in the analysis of the historical record at these sites. It is important to note that the winter of 2002–03 was a low snow season, and results from these analyses may therefore have limited application to historical data. These relationships will be improved upon with additional data in future years. As well, future work will focus on the ablation season.

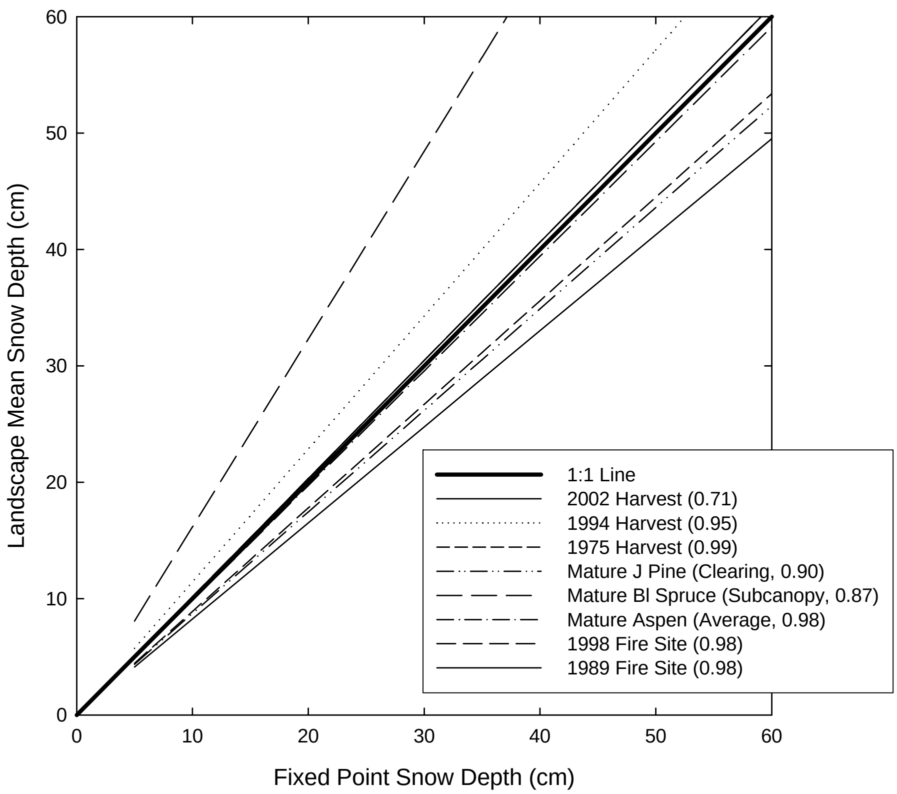

Figure 2. Relationship between fixed point snow depth and snow survey mean depth for BERMS sites (SR50 location and R^2 values given in brackets). SR50 data were unavailable for the fen. These results are for the accumulation season only.

This type of analysis is useful where there are sufficient snow survey measurements available, but a different approach would be needed if the resources were not available to conduct regular surveys. Under these conditions, researchers may choose to install multiple automated sensors at a site. The minimum number of instruments will depend on the desired accuracy as well as on both the mean depth and the spatial variability (Hicks, 1973), which can only be assessed using snow surveys or by comparison with similar landscapes. For the BERMS sites, the minimum point sample sizes that would be needed to represent the landscape mean within 10 to 50% were determined (Figure 3). The minimum number required to represent the mean within ±25% ranged between 3 and 30, and, for most sites, five instruments would have adequately represented the landscape mean within 25% during the January–March period. Improved accuracy would require a prohibitive number of sensors. The curve determined for the fen for the early part of the season used only one snow survey and will be improved upon in the future. The results shown in Figure 3 are for randomly located sensors; thoughtful site selection and preparation are still required to ensure that the small number of point measurements will adequately approximate the landscape mean.

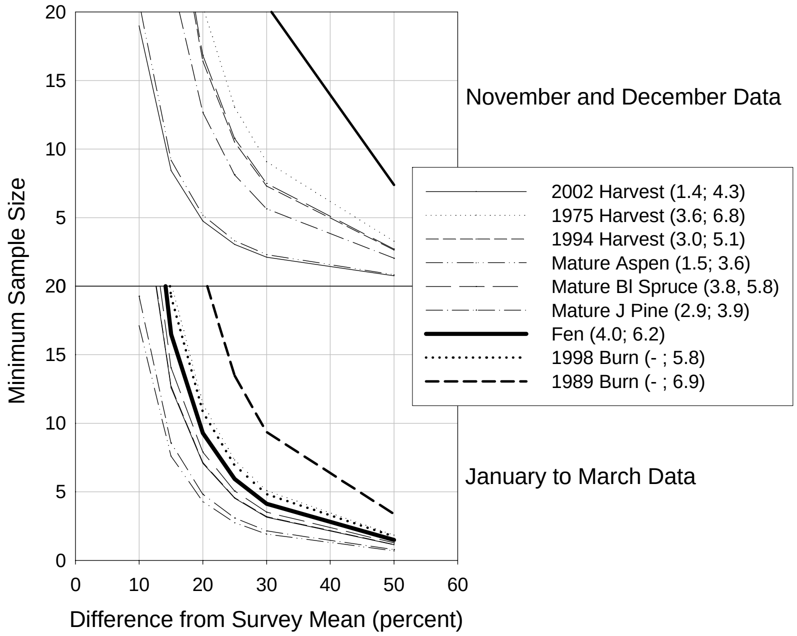

Figure 3. Minimum sample size results for varying levels of accuracy. Results were determined for the low-snow season in November and December, and for the peak season from January to March. The mean standard deviation in depth is given in brackets (Nov–Dec; Jan–Mar).

The results of this analysis clearly showed the importance of assessing fixed point snow depth measurements in the context of within-landscape spatial variability, and the essential information that can be derived from regular snow surveys at a site. The relationships between the fixed-point measurements and the landscape mean have implications when using historical observations for climatological and hydrological analysis, in comparisons with spaceborne data, and for decision-making with regards to the design of snow depth observing networks. Researchers who use any snow depth observing network archive should approach their analysis with these considerations in mind.

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