MEASURING SNOW INTERCEPTION AND LOSS FROM AN ARTIFICIAL CONIFER

by

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INTRODUCTION

Small clearings created by harvesting timber often accumulate snowpacks with more water than snowpacks in surrounding forests, on subalpine watersheds in Colorado, U.S.A. According to Wilm and Dunford (1948) and Goodell (1959), harvesting reduces or eliminates evaportaion of snow intercepted on the forest canopy. More recently, Hoover and Leaf (1967) attributed the difference to wind redistributing snow from the surrounding canopy into the harvest area, a conclusion Troendle and King (1985) questioned.

Computer-controlled instrumentation provides opportunities to quantify the environmental factors contributing to both wind redistribution and interception evaporation. Experiments aimed at the redistribution process are described by Schmidt and Jairell (1987), Schmidt and Troendle (in process), and Troendle et al. (1988). This paper begins a series on the relationship between snow interception loss and the factors that control it.

Experimental methods and theory have advanced since Goodell (1959) made initial steps toward quantifying snow interception loss. Electronic sensors measuring interception and the factors controlling its loss provide greater accuracy than was available earlier (e.g., Satterlund and Haupt 1967). An expression for sublimation of wind-blown snow, in terms of particle surface area, ambient temperature, humidity, radiation, and ventilation rate (Schmidt 1972), predicts losses observed in the plains environment (Tabler 1975). The first step in testing an analogous model for snow intercepted by a forest is to develop a technique sensitive enough to measure loss from a single tree over short periods, when environmental factors may be considered constant. This paper reports such a device, and the initial tests to determine its suitability.

Designed and constructed in Laramie, Wyoming, during January 1988, the apparatus was installed near the headquarters of the Fraser Experimental Forest in central Colorado at the end of January. Continuous testing during the following 8 days recorded both interception and evaporation of a moderate snowfall. The main objective of this paper is to describe the device and its performance, although some example measurements with the associated environmental factors are also presented.

DESCRIPTION OF THE DEVICE

A tripod of steel pipe (Fig. 1) supports a vertical shaft of thin-walled conduit that transfers the weight of an artificial conifer to an electronic balance beneath the tripod. To reduce temperature fluctuations, an insulated box encloses the balance. Triangles of plywood (3/4 in) attached to the tripod legs maintain a snow-free area around the scale box (Fig. 2).

Low-friction plastic bushings are loosely fitted to minimize mechanical drag on the transfer shaft, which rides on a plastic plate where it touches the scale. A cap clamped to the shaft prevents snow from fouling the upper bushing, and PVC pipe shields the lower bushing and the opening where the shaft enters the scale box (Fig. 3). A cross-arm on the tripod supports environmental sensors.

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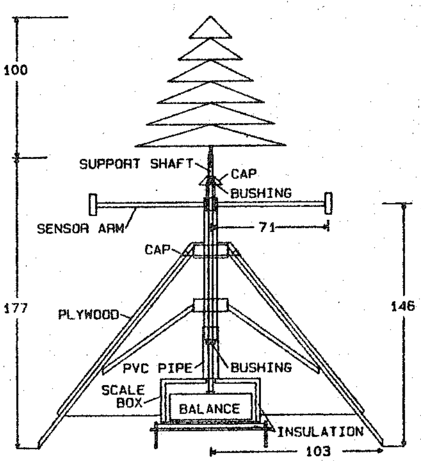

Figure 1. Diagram of the apparatus, showing major dimensions in centimeters.

Figure 2. Photograph of the device installed for testing, with one plywood face removed to show the tripod frame and scale box.

The electronic balance (Mettler Model PK36)* weighs up to 36 kg with resolution of 1 g, or any 6 kg within this range with resolution of 0.1 g. These measurements are relayed by serial data transfer, through a 20-mA current loop, to a computer housed in a mobile laboratory (Fig. 4). The computer controls all functions of the balance, including zero offset, averaging time, and measurement.

An artificial conifer formed of plastic needles wrapped in wire branches provided interception for initial tests of the technique. The extruded plastic needles had a star-shaped cross section of 0.6-mm outside diameter, and 64-mm length. This choice eliminates the desiccation that would complicate measurements if a real tree was cut for the purpose.

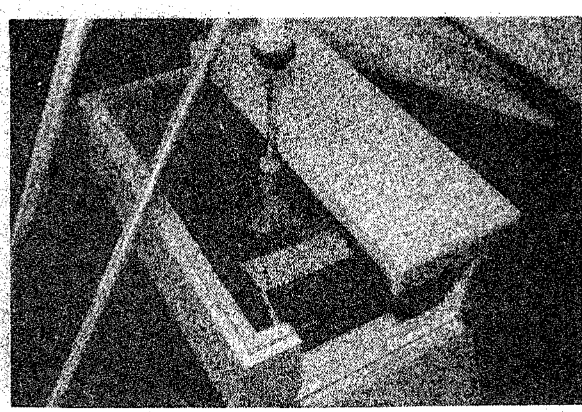

Figure 3. The support shaft enters the scale box through a hole that is shielded from snow by PVC pipe.

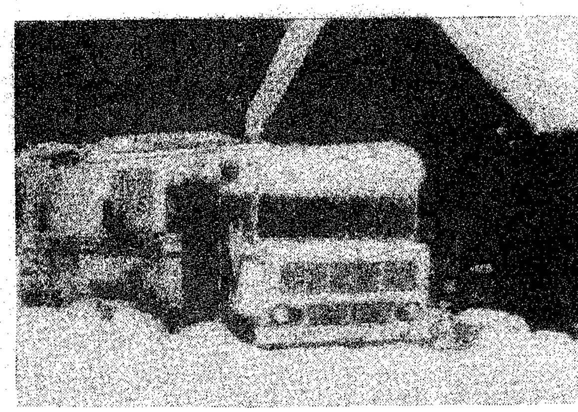

Figure 4. Data from the electronic balance and sensor signals for environmental factors were recorded in this mobile van 50 m from the measurement site.

PERFORMANCE

Temperatures in the scale box are sufficiently stable to prevent errors in zero offset of the electronic balance (Fig. 5). Zero values (with the weight removed from the balance) showed a variation of only 0.2 g over 24 h during the tests, with no deviation in readings during each 10-min check.

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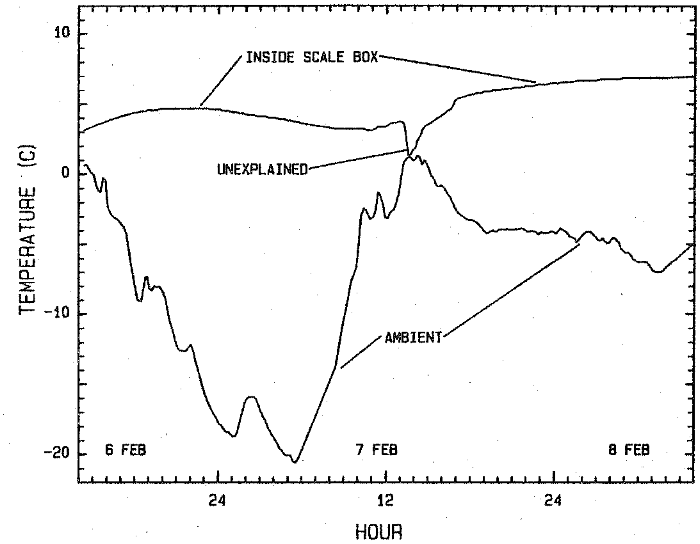
*The use of trade and company names is for the benefit of the reader; such use does not constitute an official endorsement or approval of any service or product by the U.S. Department of Agriculture to the exclusion of others that may be suitable.

Figure 5. Insulation in the scale box moderates ambient temperatures so the electronic balance operates within the range specified by the manufacturer. The cause of the drop to ambient at 1400 h on 7 February could not be traced.



Variations in measured weight were strongly correlated with wind, as demonstrated by a plot of 1-min average readings (Fig. 6). A large deviation from the mean weight of snow occurred during a lull in wind at about 1800 h. This was attributed to a tendency for the vertical support tube to hang on the support bushing. A very slight breeze brought measurements back near the mean. Small modifications that eliminate the lower bushing will reduce this problem in future experiments. Variations created by wind drag must be averaged over 10-15 min periods.

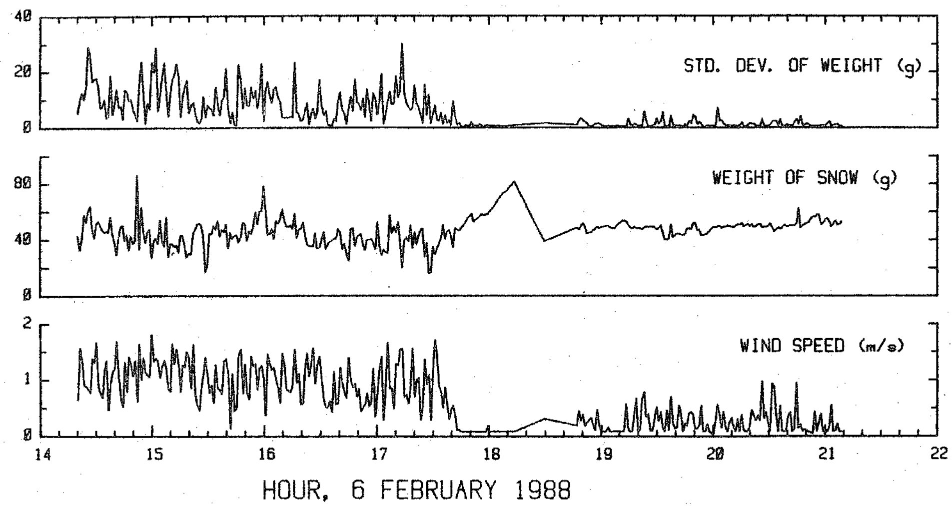
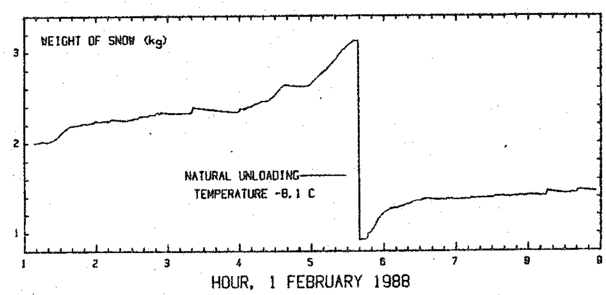


Figure 6. Wind drag on the tree produces variations in the readings that must be averaged. Friction between bushings and support rod is assumed to cause the large deviation during a lull at 1810 h that disappeared with a slight air movement at 1820 h.

EXAMPLE MEASUREMENTS

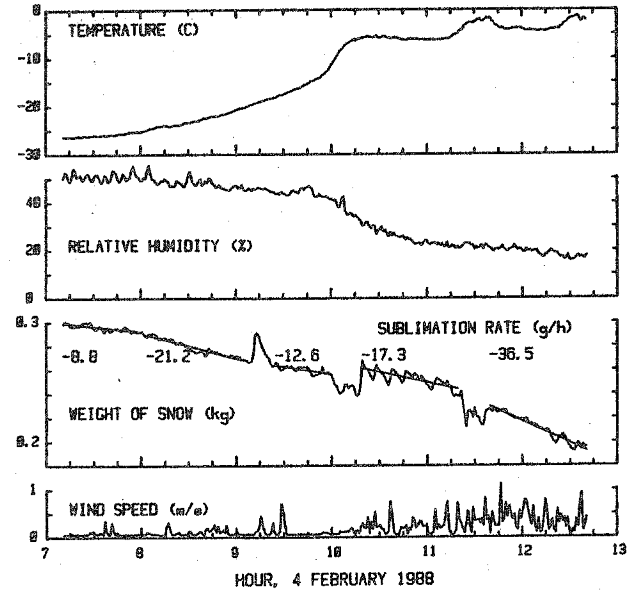
Recorded weights of intercepted snow during several periods of the tests (Fig. 7a) demonstrate the use of the apparatus. A sharp drop in weight during snowfall at 0540 h on 1 February corresponded to a cascade of intercepted snow from overloaded branches. A similar weight loss occurred after a second snowfall added almost 4 kg to the tree, which unloaded when we opened a clasp on the scale box to check the level of the balance. Snowload release by the flexing of artificial branches may not match that of real conifers. Forces required to deflect real branches during the test period showed a strong decrease with warming temperatures (Pomeroy and Schmidt, in preparation).

Sublimation of intercepted snow depends directly on snow surface area and energy available for the phase change from ice to water vapor. The period 0700 to 1300 h on 4 February (Fig. 7b) showed average sublimation rates from -9 to -36 g h^{-1} under warming, with increasing wind and decreasing relative humidity. During this period, one-third of the snow remaining on the artificial crown sublimated.



(a). snow interception

Figure 7. Example measurements during
(a) snow interception and
(b) sublimation.



(b). sublimation

CONCLUSIONS

A device that weighs snow intercepted by a small, artificial conifer provided sufficient accuracy to determine interception lost to sublimation over periods as short as 10-15 min. Computer control of the electronic balance allows compensation for weight variation due to wind drag. Differences in branch flexure and energy balance between real and artificial trees must be considered before this device is applied to experiments on sublimation of snow intercepted by a forest canopy.

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