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SNOW DEPOSITION AND MELT UNDER DIFFERENT VEGETATIVE COVERS IN CENTRAL NEW YORK

Two-thirds of the annual runoff from watersheds in the Allegheny Plateau of central New York comes from the snow—or snow and rain—that falls in December through April. Although the amounts of precipitation in this period are fairly uniform from year to year, the proportion that falls as snow varies; so does the amount that accumulates on the ground, and its duration and rate of melt. The differences in ground cover also affect snow deposition and melt and the timing and amount of runoff from this snow.

The Study

To determine the relative amounts of snow deposition and melt on open land and under forest stands of different species and densities, snow depth and water equivalent were measured at 23 weekly intervals on the Tully Forest of the State University of New York College of Forestry, 20 miles south of Syracuse, in the winter and spring of 1961-62.

Seven snow courses were laid out to traverse five cover types commonly found on the Allegheny Plateau: (1) open land (unimproved pasture), (2) brushy hardwoods, (3) northern hardwoods, and (4) red pine and (5) Norway spruce plantations. In the brushy-open hardwood type thorn-apple, (*Crataegus* spp.) was the most conspicuous component, but hardwood saplings, berry bushes, and other shrubs were common. The pine and spruce plantations were about 30 years old, and each included both a dense and a thinned stand. The dense stands still exhibited the approximately 6 x 6 feet spacing used in their establishment. The thinned Norway spruce stand had also been pruned. In the all-aged northern hardwood stand, occasional stems 20 inches in diameter at breast height were found.

Each snow course was roughly 100 feet long, divided into 10 equal sampling segments in which sampling points were randomly located. All the courses were within 1 mile of one another at elevations of 1,900 to 2,000 feet on slopes of less than 10 percent, oriented approximately southwest.

Table 1 shows the basal area and sum of diameters derived from a tally of all the trees 1 inch and more in diameter at breast height, on strips 66 feet wide centering on the snow courses, and the average of crown-closure measurements made at each sampling point with a densiometer.[1]

Table 1.—*Cover conditions on snow courses*

Cover type	Basal area	Sum of diameters	Crown density
	Sq. ft./acre	*Inches*	*Percent*
Open land	0	0	0
Brushy hardwoods	31	1,553	2.8
Northern hardwoods	133	2,930	7.6
Red pine, thinned	109	2,486	85.
Red pine, dense	196	5,253	93.
Norway spruce, thinned	163	5,269	94.
Norway spruce, dense	139	5,255	96.

A record of air temperature was obtained from a thermograph and maximum-minimum thermometers exposed at a central location on the Forest. Data for a number of missing days of record were estimated on the basis of the relationship to a nearby Weather Bureau cooperative station at Cortland, N.Y.

The period November 1961 to early April 1962 was one of less than normal precipitation. Most of the months showed small departures from the long-term average, but March had 1.64 inches less precipitation than normal. Not only was the total precipitation less, but the proportion that fell as snow was less than the average of the past 30 years.

[1] Lemmon, Paul E. A SPHERICAL DENSIOMETER FOR ESTIMATING FOREST OVERSTORY DENSITY. Forest Sci. 2: 314-320, 1956.

Results

There was a continuous fluctuation in snow water equivalent throughout the measurement period. Successive weekly measurements indicated snow accumulation, melt, or both. However, there was a general overall increase in water equivalent of the snow on the ground up to March 3 on the open, brushy hardwood, northern hardwood, and thinned Norway spruce plots, and up to March 23 on the others.

Snow accumulation.—In the middle and later winter period snow was most variable on the brushy hardwood site, accumulating most readily here, but also melting fastest. The open plot accumulated less largely because wind blew some snow away; this plot also lost snow readily through melt, a pattern that paralleled that on the brushy hardwood site, but at a lower level. The northern hardwood stand tended to accumulate snow at a slightly lower rate than the brushy stand, and tended to lose it at a slightly slower rate, giving a similar net effect.

Maximum accumulation on hardwood and conifer sites reflects the balance between precipitation, interception, and melt. Average maximum snow water equivalents for the six forest-cover conditions (table 2) are approximately in reverse order of the crown densities of the stands in which they were measured. The accumulation on the brushy site was not significantly different from that under the denser northern hardwoods.

The sum of the positive increments between sampling dates gives an expression of the cumulative effect of cover on snow deposition over the entire season (table 2). This expression is probably a better index of the overall effect of the different cover types than the maximum accumulation on the ground at any one time. Total accumulations under the spruce and dense red pine stands are probably close to the actual values; here most of the snowfall remained on the ground until it was measured. For the hardwood stands, the open site, and the thinned red pine stand the values shown are underestimates, the amount varying inversely with the cover density.

Values of total accumulation for the entire period of the study are inverse to crown density for tree- and shrub-covered sites and show a wider range in values than the maximum accumulation. On the brushy hardwood site the total accumulation for the season is 1.9 times that under the dense spruce, although only 1.6 times as much was present on the ground at the time of maximum accumulation.

Significance of difference.—Analyses of variance of mean water equivalents for each sampling date showed that differences significant at the 5-percent level existed among the cover types whenever there was snow

Table 2.—*Measured snow accumulation, in inches of water*

Cover type	Maximum accumulation on ground	Total accumulation Nov. 30 to April 27
Open land	2.25	6.07
Brushy hardwoods	5.15	9.23
Northern hardwoods	4.90	7.28
Red pine, thinned	4.90	6.44
Red pine, dense	4.05	5.33
Norway spruce, thinned	3.05	5.13
Norway spruce, dense	3.25	4.80

on the ground. Subsequent least significant difference computations generally showed differences between the mean values of all possible pairs to be significant, with few exceptions. For instance, there was no difference between the water equivalents of the thinned and unthinned spruce stands on February 1 and 23 and all through March. Other instances of similar average water equivalents probably do not reflect physical similarities of the stands so much as fortuitously similar results of a number of factors influencing accumulation and dissipation in different degrees.

Ice and snow density.—An unusual but probably not unique occurrence was the presence of solid ice on the soil surface and in the litter under the dense spruce stand from January 4 to the end of the study. This started as a layer of rain that froze in the shallow snow but, once established, did not disappear. The thickness of the ice varied little over the plot, but increased in depth with partial melt and refreezing. There was also a gradual change in the type of ice, from a thin continuous layer to thicker granular ice, and finally to a thick (1½ inch), clear, dense, hard ice. At times there was evidence of meltwater flowing over the frozen surface, as indicated by small channels and by areas where needles were deposited by the moving water, but the ice surface remained intact. The water equivalent of this ice layer is included in all estimates of water equivalent for the dense spruce stand. This ice layer persisted through several days with maximum temperatures over 80°F. A similar layer formed under the thinned spruce stand, but it became discontinuous and disappeared before the end of the study.

Average snow density tended to increase to approximately 30 percent just prior to rapid melt. This is in general agreement with observations made in the Adirondacks and in New Hampshire. The presence of the layer of ice in the spruce stand obscured this relationship somewhat.

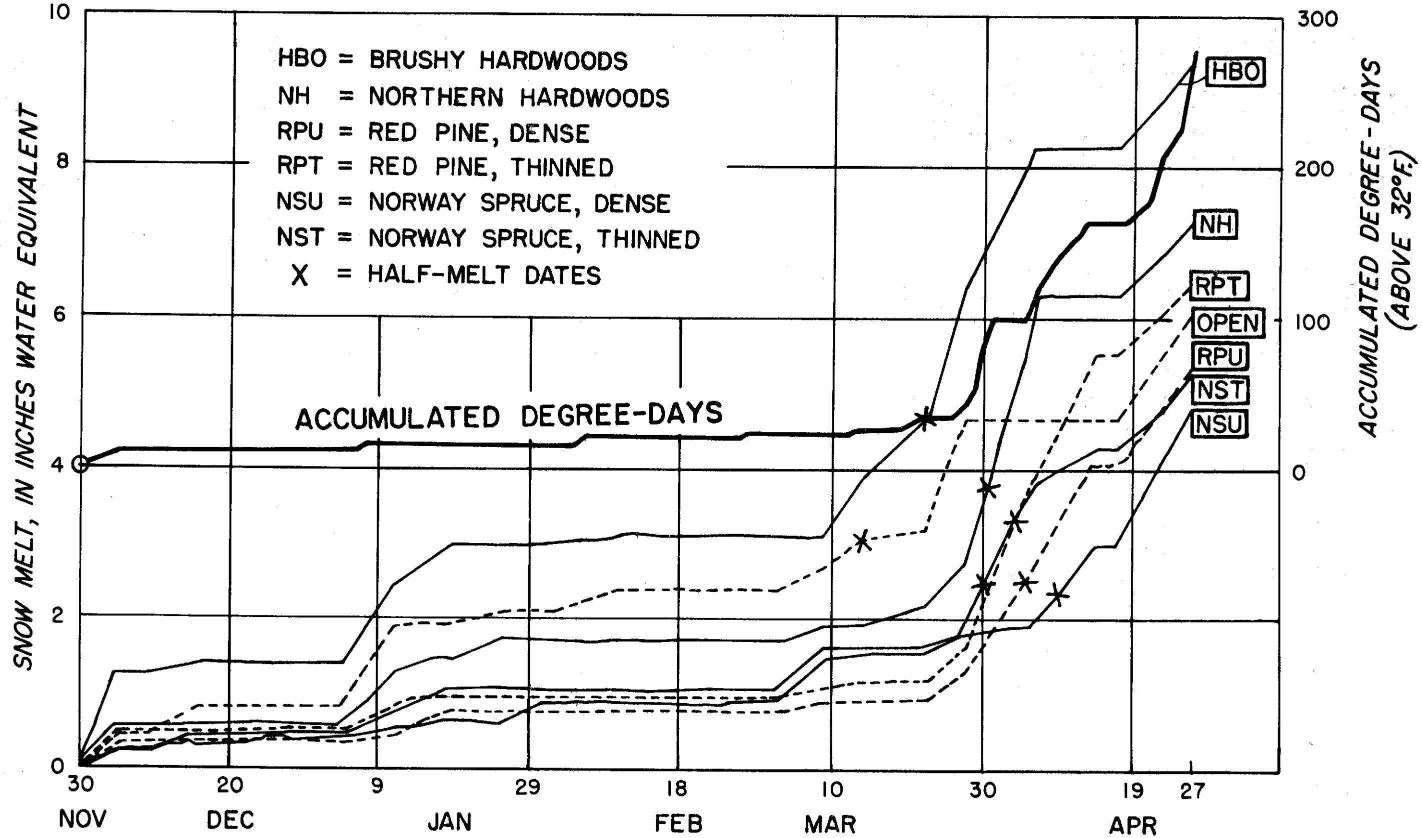

Figure 1.—Cumulative snow melt on the Tully Forest. Southwest aspects, 0 to 10-percent slopes, elevation 1,900 to 2,000 feet.

Half-melt date.—The accumulated degree days and accumulated snow melt shown in figure 1 illustrate the striking differences associated with the different cover conditions. The date when half of the seasonal snow melt has taken place may be related to the prolonged high stream discharge rates during the snow-melt period (a possibility suggested by Arnold Court's half-flow date[2]). For instance, by March 15 and 23, before the first real spring warm spell (which started about March 28), half the seasonal accumulation of snow disappeared in the open and brushy hardwood sites, and the ground was largely bare except for some drifts in the brushy area. The halfway point in the northern hardwoods and thinned spruce was reached about March 31, in the red pine stands about April 4 and 5 and in the dense spruce 5 days later. The most rapid melt of the season occurred under the northern hardwood stand during this period, and extended rapid melt also occurred under the thinned conifers. Under the dense conifers melt was somewhat slower and the more rapid rates occurred later.

Snowmelt runoff.—The longer the snowpack persists, the greater is the likelihood of rapid melt rate and consequent rapid runoff, as the transition from cold winter proceeds into the warmer conditions of spring—greater the likelihood, too, of heavy rainfall swelling snowmelt runoff from the ripe snowpack. It appears that the timing of high temperatures or amounts of rainfall may change the forest's influence on snow accumulation and melt from favorable to unfavorable. When the critical warm period comes early, with large snowpack accumulations in both fields and forests, forests probably contribute less and slower runoff than open areas; when warm weather comes late, with an appreciable snowpack only in forests, the reverse should be true. Consequently, a mixture of forest cover and open areas may provide the best land-use control of snowmelt runoff on the northern Allegheny Plateau.

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[2] Court, Arnold. LARGE MELTWATER FLOWS COME LATER. U.S. Forest Serv. Pacific Southwest Forest and Range Expt. Sta. Res. Note 189. 8 pp., illus, 1961.

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