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THE EXTENT TO WHICH THE SNOW BLANKET INFLUENCES THE TEMPERATURE BENEATH IT

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THE PROBLEM

Snow cover has long been known to exert a blanketing effect, influencing both the absorption and loss of heat by the surface of the earth. This effect is inferentially of considerable importance to the root systems of plants, the shoots of low-growing vegetation, and many species of animals. Palmer,[1] of the U. S. Weather Bureau, conducted a study extending over a period of 8 days during which a range of air temperature of 34° F. occurred. He reported a range of 25° under two inches of snow, 14° under four inches, 3° under eight inches, 1° under twelve inches, and no range under 24 inches. He found that a two inch snow cover reduced the daily heat exchange between earth and air almost one-third, while four inches of snow reduced it almost two-thirds. Brooks[2] reported the following series of readings obtained one morning in 1923 in New England; air temperature, —8° F.; surface of the snow, —16° F.; beneath a four inch snow cover, 7° F.; beneath a five inch snow cover, 10° F. In February, 1899, in Washington, he found the temperature at the bottom of a 13 inch snow cover to be 31° F. when the air temperature was —15°. As one of the outcomes of a study conducted at Bozeman, Montana, during the cold February of 1936, Mail[3] reports a minimum temperature of —7° C. under a snow cover of eight to fifteen inches, while the air temperature dropped to —41.7° C. during the month.

THE PRESENT STUDY

The abundant snows during the past winter in Minnesota afforded a very good opportunity to undertake a somewhat more extensive study of the problem. It is to be regretted that the experimental work was delayed until after the coldest period of winter had passed. One unexpected difficulty arose. The plan to use maximum-minimum indicating thermometers was finally abandoned, after returning one or two instruments to the manufacturers

[1] Palmer, Andrew H. Snow and Its Value to the Farmer, Scientific Monthly, Vol. 6, pp. 128–141, 1918.
[2] Brooks, Charles F. How Snow Keeps the Earth Warm, Lit. Dig., Vol. 76, pp. 61–62, Mar. 31, 1923.
[3] Mail, G. Allen., Soil Temperatures at Bozeman, Montana, During Sub-Zero Weather, Science, Vol. 83, page 574, June 12, 1936.

for inspection, when it was learned (by trial and error largely) that the mercury column tends to pass the indicators when the thermometer is placed in a horizontal position. Subsequently, ordinary thermometers were fastened to the ends of long wooden rods and thrust back under the snow. Upright rods bore the thermometers to record air temperature. Some records were obtained between February 7 and February 16, 1937. Readings were taken regularly, except for a few interruptions, from February 17 to March 13, at 8:00 A.M., 12:00 NOON, and 5:45 P.M. In addition to the temperature readings, note was made of the condition of the snow, the sky condition, and the wind velocity in the attempt to discover whether they influenced the blanketing effect of the snow. The snow cover was maintained at thicknesses of 3, 6, 9, and 25 inches at the station through scraping off the additional snow which fell and, in one instance, by adding loose snow. There is not space here to reproduce all of the readings obtained. The data are summarized in tabular form. All readings are fahrenheit.

COMPARISON OF AIR TEMPERATURE WITH THAT BENEATH THE SNOW

	Low	High	Average	Range	Ave. Daily Range*
Air	—10°	48°	18.7°	58°	12.0°
Under 3″ snow	12°	32°	25.3°	20°	5.9°
Air	—10°	48°	21.6°	58°	14.4°
Under 6″ snow	18°	32°	27.9°	14°	3.7°
Air	—10°	44°	21.1°	54°	15.2°
Under 9″ snow	16°	32°	26.4°	16°	2.6°
Air	—10°	48°	20.6°	58°	13.7°
Under 25″ snow	19°	31°	28.8°	12°	1.0°

* Calculation based on early morning, noon, and evening readings.

Some idea of the variation in temperature beneath the different thicknesses of snow cover as the air temperature changed may be gained from the line graphs. The three readings shown for each day are those of the early morning, noon, and evening respectively.

DISCUSSION

These results are in general agreement with those obtained by other workers in showing that a snow cover exerts a marked blanketing effect.

The effectiveness of cover in reducing diurnal changes proved approximately proportional to its thickness, the average variations under 3, 6, 9, and 25 inches of snow being approximately 49, 26, 17, and 7 per cent respectively of the average daily range in air temperatures. For considerable periods of time when no great range in

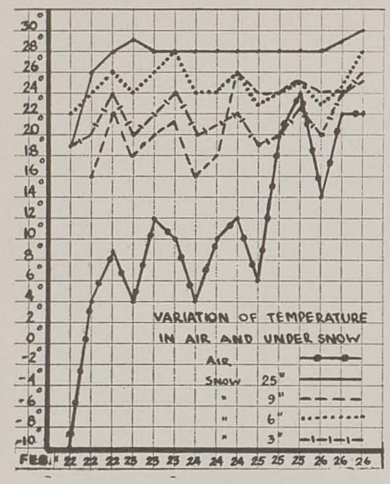

FIGURE 1

Blanketing Effect of Different Thicknesses of Snow Cover during Late February.

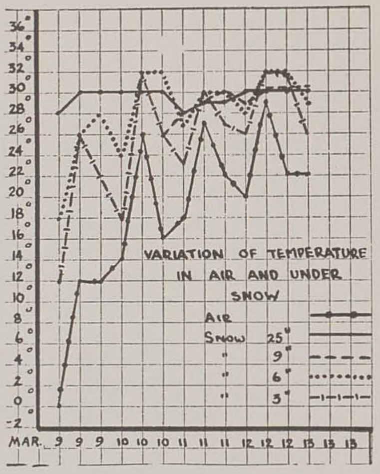

FIGURE 2

Blanketing Effect of Different Thicknesses of Snow Cover Shortly before the Snow Melted.

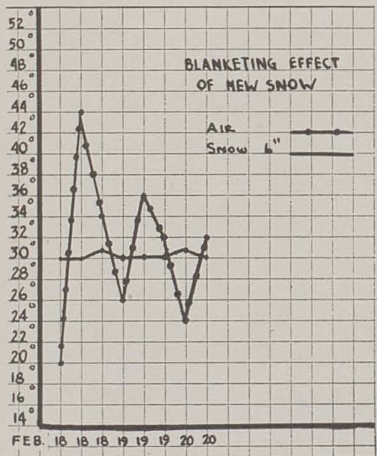

FIGURE 3

A Six-inch Cover of Fresh Snow Forms a Good Blanket.

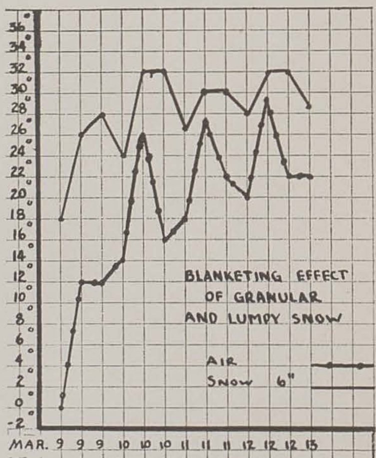

FIGURE 4

Decreased Blanketing Effect of an Altered Snow Cover.

air temperatures occurs, the temperature under 25 inches of snow remains unchanged. This may explain Palmer's finding that no range occurred at the bottom of a 24-inch cover.

The average temperature under a three-inch snow cover was only 3.5° F. lower than under twenty-five inches of snow, but the average daily range was almost six times as great.

The effectiveness of a light snow cover (3 to 6 inches) seems to depend to a considerable extent on the condition of the snow. Fresh snow proved much more effective than granular and lumpy snow resulting from partial melting and refreezing. This effect was not evident in the case of a heavy snow cover, although it should be noted that the deeper snow did not undergo as much change as did the thinner layer.

These data in general tend to bear out Palmer's conclusion that the changes in temperature beneath the snow lag behind those in the air, although in some cases no such delay could be discovered. Where evident, the lag was only a few hours under 3 inches of snow, while it was as much as twenty-four hours under a 25-inch cover. Comparison on the basis of either wind velocity or sky condition failed to reveal a reason for a lag in some cases and its absence in others.

Some data were obtained which tend to show that the depth to which the ground freezes is influenced by other factors as well as the thickness of the snow cover. The frost depth was found to vary from 0 to 21 inches. The greatest thickness of frozen ground was discovered in fall plowed fields under a snow cover of 23 to 26 inches. However, the limited range of the data and the fact that the snow cover in open fields shifts with the wind makes any definite conclusions unwarranted.