SLIDE RULE FOR SNOW FENCE DESIGN

by

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INTRODUCTION

A method for determining required height and number of rows of snow fences has been used for more than 10 years to design effective snow fence systems for controlling drifts and augmenting water supplies (Tabler and Furnish, 1982; Sturges and Tabler, 1981; Tabler and Sturges, 1986). The procedure consists of designing fence systems with sufficient capacity to store the mean annual snow transport, as estimated from information on fetch distance and relocated precipitation. Although equations used for this purpose are easily solved on most hand-held calculators, they are sufficiently complex to intimidate users unfamiliar with such calculations. The technical nature of publications describing development and use of the equations is another deterrent to their application.

This paper describes a slide rule for calculating required height, storage capacity, and number of rows of snow fence, which allows these calculations to be made easily in the field even by persons lacking a technical background.

EQUATIONS FOR DETERMINING FENCE HEIGHT

Estimating Snow Transport

The method for estimating snow transport is that developed by Tabler (1975). As shown diagrammatically in Figure 1, *"fetch"* or *"contributing distance"* is the length of an area serving as a source of blowing snow to a downwind location. The upwind end of the fetch is any boundary across which there is no snow transport, such as a forest margin, deep gully or stream channel, row of trees, or shoreline of an unfrozen body of water.

"Maximum transport distance" is the distance an average-size snow particle travels before completely evaporating. Although it cannot be measured directly, this conceptual distance provides a basis for estimating the evaporation, and hence transport, of blowing snow. Although maximum transport distance varies greatly from storm to storm depending on relative humidity, air temperature, wind speed, and other factors affecting evaporation (Schmidt, 1972), season-long averages are less variable. Studies in Wyoming show maximum transport distance averages about 3.0 km (10,000 feet), and experience indicates that this value applies to a wide variety of locations, presumably because of compensating factors. Benson (1982), for example, calculated a similar value for a site in arctic Alaska,

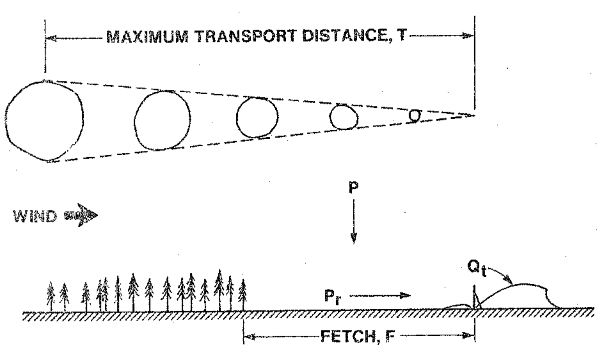

Figure 1. Diagram of transport distance concept used to estimate transport and evaporation of wind-transported snow. Transport distance, T, is defined as the average distance a snow particle (shown between the convergent dashed lines) can travel before completely evaporating. Fetch, F, is the distance contributing blowing snow to a site, and may be equal to or less than T.

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suggesting that lower relative humidities may compensate for colder temperatures and less solar radiation. Dyunin (1966) reported that transport distance does not exceed 2-5 km in Siberia.

"Relocated precipitation" is that portion of water-equivalent precipitation relocated by the wind, and therefore excludes snow retained by vegetation and topographic features over the fetch, or snow that melts in place. Studies in Siberia (Komarov, 1954), as well as in Wyoming, indicate that even on flat areas with low-growing vegetation, less than 75% of a winter's snowfall is relocated by the wind.

Assuming uniform conditions over the fetch distance, snow transport is given by

$$Q_t = 0.5P_rT\{1 - 0.14^{F/T}\} \tag{1}$$

where Q_t = Snow transport water-equivalent (cubic feet of water per foot of width)
P_r = Relocated precipitation (feet, water-equivalent)
T = Maximum transport distance in feet, usually assumed to be 10,000 ft.
F = Fetch distance (feet)

English units are used because they are appropriate for non-technical users in the U.S.A.

Estimating Storage Capacity and Required Fence Height

Total water-equivalent storage capacity of 50%-porous snow fences on level terrain is approximately

$$Q_c = 6.3H^{2.18} \tag{2}$$

where H is fence height in feet, and Q_c is storage capacity in cubic feet of water-equivalent per foot of fence (Tabler, 1980). Although this relationship is strictly applicable only to the horizontal-board "Wyoming" fence, it approximates the capacity of most 50%-porous fences provided they are not buried in the drift (Tabler, 1986). Assuming T = 10,000 ft, setting $Q_c = Q_t$, and solving for required fence height, H (ft),

$$H = 21.38\ \{P_r\ (1 - 0.14^{0.0001F})\}^{0.459} \tag{3}$$

A simplifying assumption used for the slide rule was that all winter precipitation, P, would be relocated; i.e., $P = P_r$. Although this assumption overestimates snow transport by at least 25%, over-designing storage capacity of a fence system assures efficient snow trapping. Snow-trapping efficiency declines rapidly after a fence is 75-80% full (Tabler, 1974), suggesting that storage capacity should be about 20-25% greater than snow transport.

THE SLIDE RULE

Solution of Equation (3) is given by the slide rule shown in Figure 2. Copies of these scales can be glued on paperboard with the window on the face cut out to allow the sliding scale to be visible, and the slide sandwiched with a paperboard backing. Required fence height is indicated by the arrow on the sliding scale after setting precipitation opposite fetch distance.

Other design criteria included on the slide rule include spacing of fences from the area to be protected, snow storage capacity, and required number of rows of 4.5- and 9-ft fences. Recommended distance from the road is taken to be the maximum length of the lee drift on level terrain when the fence is filled to capacity. Because this distance is 29-35 times the fence height (Tabler, 1981; Tabler, 1986), slide rule values were computed as 35H. Snow storage capacity was computed by multiplying Equation (2) by (62.4/2000).

An exact determination of the number of rows of 4.5- and 9-ft-tall fences providing approximately the same storage capacity as a fence of height H, requires consideration of precipitation falling between fence rows, and the reduced evaporation of blowing snow over that portion of the fetch occupied by fences. Although a complex equation can be derived from Equations (1) and (2), an approximation used for the slide rule was

$$N \cong (H / H_s)^{2.18} \tag{4}$$

where N is the required number of rows of fence having height H_s, and H is the height required for a single row of fence.

The preceding development has been based on storage capacity of snow fences as reported by Tabler (1980). More recent data on snow density (Tabler, 1985) and drift geometry (Tabler, 1986) indicate that snow storage capacity is more closely approximated by

$$Q_c = 6.7H^{2.2} \tag{5}$$

This suggests that Equation (2) underestimates snow storage capacity by about 10%, so that snow fence design determined with the slide rule is commensurately conservative.

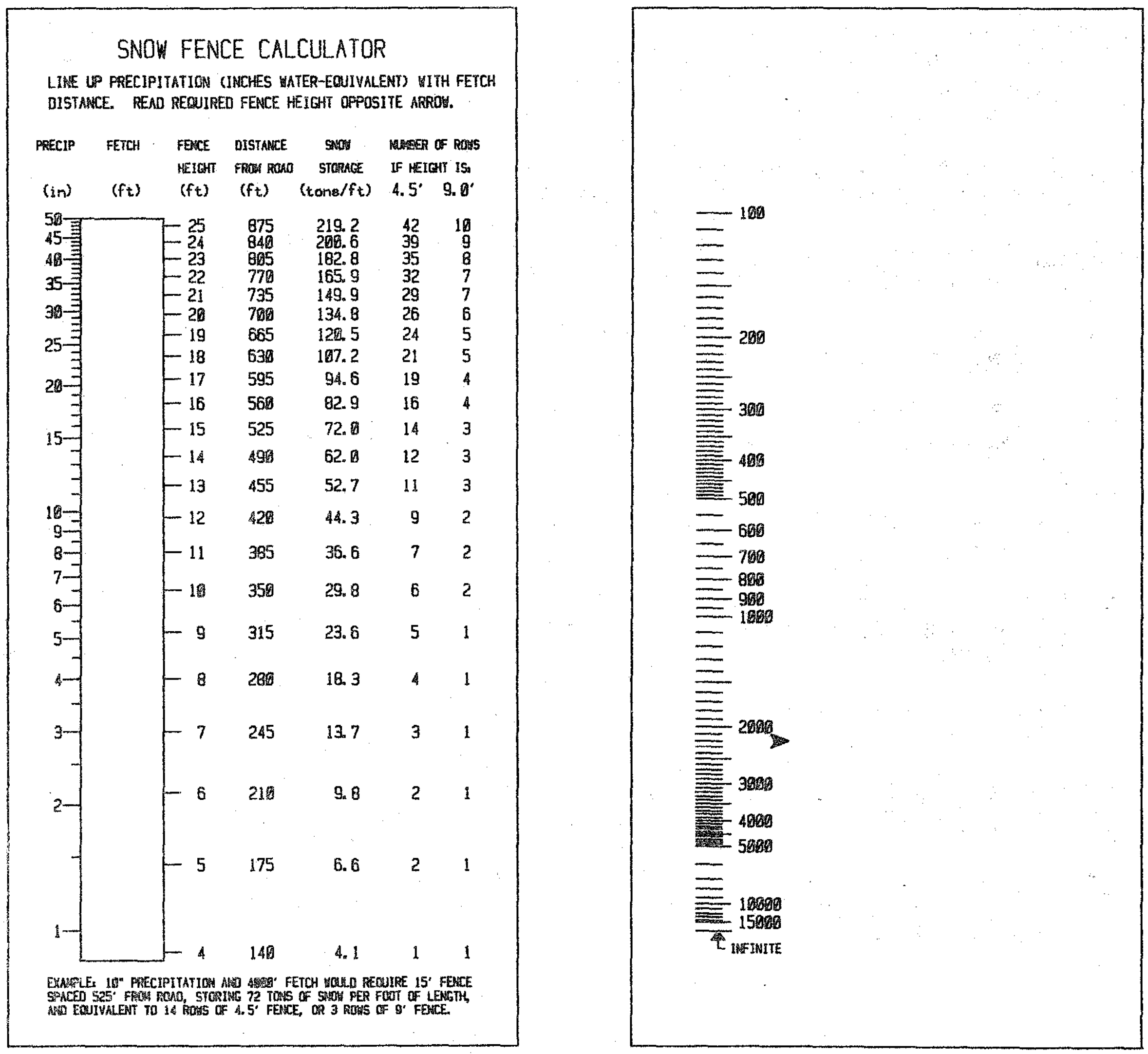

Figure 2. Slide rule for solving Equations (3) and (4) to compute required height and placement of 50%-porous snow fences on level terrain. Using total winter precipitation, rather than relocated precipitation, compensates for the decline in trapping efficiency as a fence fills. A field version may be constructed by gluing these scales on paperboard.

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