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Snow Management and Windbreaks

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Introduction

Anticipating and planning for winters can save farmers and ranchers money with proper snow management and windbreaks. This paper describes tools developed by the U.S. Forest Service to control wind and blowing snow. The discussion updates reviews (Jairell and Schmidt 1989, 1991) of more detailed papers listed as references, available by request to the mailing address given at the end of the paper. Additional information is also available on the Internet at http://www-wrrc.uwyo.edu/wrds/rmfres.

Techniques for wind screening discussed here are (1) permanent livestock protection shelters, and (2) temporary, portable windscreens. Practices to control snow accumulation are discussed under the following broad objectives:

1. Preventing snowdrifts on roads, around buildings, corrals, or inside livestock shelters. Snow fences or shelterbelts are the most common methods. Buildings and shelters can be planned and located to avoid drifts in critical locations.

2. Accumulating snow in drifts as a water source. Snow fences or shelterbelts are the most effective methods, but excavated stock ponds can be designed to enhance drift formation as a source of water.

3. Retaining snow on the ground to recharge soil water or reduce snow transport downwind. Usual methods include leaving stubble or crop residue and managing vegetation to provide roughness to protect the snow cover from erosion. Grass barriers, tree rows, fences, or snow ridges also can be used for this purpose.

Livestock Shelters

When cold winter winds come to the high plains, often accompanied with blizzards, livestock look for shelter. Because natural protection is usually not available, some producers build artificial barriers (Fig. 1) to provide shelter from wind and drifting snow (Jairell and Tabler, 1985). Jairell and Schmidt (1988) reported the effects these shelters have in deflecting drifting snow and reducing wind speed. But what about their impacts on livestock production? The most tangible benefit is the reduction in feed required by the animal to maintain its body condition over the winter. Combining results from the studies on wind and drift protection with other research on animal food requirements at cold temperature gives us an estimate of how cost-effective blizzard protection can be.

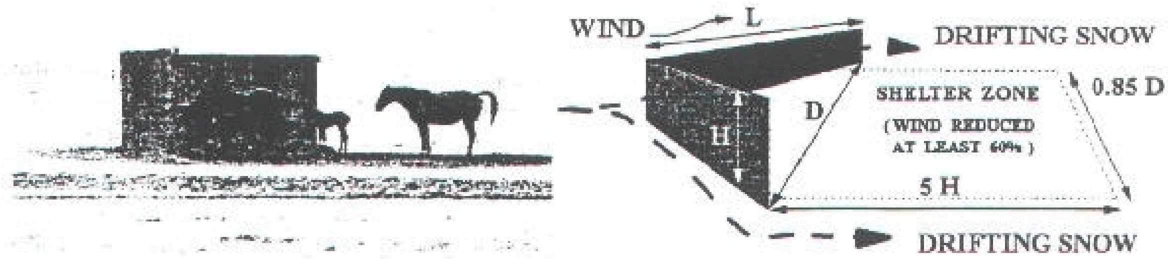

Figure 1. A 90-degree "V"-shaped protection barrier reduces wind speed by at least 60% in a shelter zone extending 5 times the barrier height downwind. To divert drifting snow around the shelter zone, the barrier must be solid (not porous), with dimension D less than 15 H.

Shelter Size and Costs

To shelter animals from both wind and drifting snow, barriers must be constructed with a solid face that diverts drifting snow around the ends of the barrier. Otherwise, blowing snow sifts through the porous shelter and forms drifts in the protected area. A porous barrier (one with gaps between the face boards) acts like a snow fence. It creates the greatest wind reduction, but it is a poor design for protecting animals from blizzards (Jairell and Schmidt 1988).

For optimum deflection of drifting snow, the shelter width D should be no more than 15 times its height H. This means that both height and length L must be adjusted to provide the required protection area for a given herd size. Build it longer than 15 times its height, and enough drifting snow is forced up, over the top of the barrier, to create drifts in the shelter zone (Jairell and Tabler 1985).

For Table 1, we defined the protection zone as that area (A) where wind speed is reduced by at least 60%. The number of animal units (AUs) that will crowd within that shelter zone was estimated for a range of barrier heights (Meiman 1991). Length L of each 45-degree wing was chosen to give the optimum shelter width, D=15H.

Table 1. Number of animal units (Aus) protected by barrier heights H.

Height (H) (ft)	Wings (L) (ft)	Width (D) (ft)	Area[1] (A) (ft)	AUs
6	60	85	3,964	79
8	80	111	7,047	141
10	105	148	11,824	236
12	125	176	16,828	336
14	145	205	22,714	454

[1]Area of protection zone with 60-80% wind reduction.

Typical shelter construction uses vertical support posts embedded in the ground, connected with horizontal members that support the covering. Again, these shelters should have a solid face--no holes or gaps. Cost estimates in Table 2 (Meiman 1991) compare shelters using the same support member construction covered with 1-by-12 inch planks, or 4-by-8 ft sheets of 3/4 inch painted chipboard.

Table 2. Costs of materials to provide at least 60% wind reduction.

Height (ft)	Planks		Sheets	
	Cost	Cost/AU	Cost	Cost/AU
6	$789	$9.89	$480	$6.07
8	$1,384	$9.82	$833	$5.91
10	$2,251	$9.54	$1,348	$5.73
12	$3,198	$9.52	$1,908	$5.68
14	$4,311	$9.50	$2,564	$5.65

Shelter Benefits

Studies at the Ft. Keogh Livestock and Range Research Laboratory in Miles City, Montana suggest that daily maintenance requirements for cattle increase about 1% for each degree Fahrenheit (ºF) below a lower critical temperature (LCT) near 0 ºF (Ames 1989). Lower critical temperature is the point below which the animal begins to burn reserves (lose weight) to maintain body temperature. The exact values of LCT depend on type of animal (steer, cow, calf), on body condition, and whether the animal was already exposed to cold--acclimatization.

For our purpose of estimating shelter benefits, the 1%/ºF-day rule-of-thumb is a useful average. If the temperature dropped to -5 ºF at sunset, for example, and held steady for 12 hours, then jumped back above 0 ºF, animal exposure would be 60 ºF-hours, or about 2.5 ºF-days. An increase of 2.5% in the daily feed ration would be required to maintain animal weight.

Wind greatly increases heat loss from animals, as well as humans. Strong winds may further increase cattle heat loss by parting hair and reducing the insulation of the hide (Ames and Insley 1975). One way we index the effect of wind is the chill factor, the no-wind temperature that would produce the same heat loss that wind of a given speed produces at the actual temperature. For example, if air temperature is 20 ºF, a wind speed of just 12 miles per hour creates the same heat loss as in still air at 0 ºF. The chill factor is 0 ºF.

To see how effective wind protection might be, we obtained Weather Service hourly records for the airport at Laramie, Wyoming, for the 1990-91 winter, and computed the reduced feed requirements, based on the reduced chill factor. We assumed an average wind reduction of 70% in the 60-80% protection zone (Table 3). Additional feed was required on 37 days, to maintain weight on range cattle in the open. Wind protection reduced that requirement to 6 days, 5 in one cold spell just before Christmas.

Table 3. Effect of wind protection (70% reduction) on chill factor, using hourly weather records for Laramie, Wyoming airport, 1990-91.

	Deg-days below 0 °F		Days with chill factor below 0 °F	
Month	In Open	Sheltered	In Open	Sheltered
Nov '90	27	0	5	0
Dec '90	277	84	14	5
Jan '91	106	3	11	1
Feb '91	14	0	4	0
Mar '91	12	0	3	0
Totals	436	87	37	6

Over the 1990-91 winter, wind protection would have reduced the amount of additional feed required to maintain animal weight from 436% of a daily ration to 87%, based on the 1 %/°F-day rule-of-thumb. For feed costs of $1/head per day, this amounts to saving $3.49/head over the winter. Feed savings would match the cost of the shelter in 2-5 years, depending on the costs listed in Table 2, and how actual feed costs compare to $1/head per day. (The 1990-91 winter was relatively mild for Laramie.)

Other benefits from wind protection include the convenience of feeding in the protected area, and the benefits to breeding cows that come through the winter in better body condition. The benefits of this wind protection technique only apply to situations where animals are otherwise exposed to wind. No shelter benefit occurs during periods of extremely cold, but calm air.

Temporary Protection

Portable shelters (Fig. 2) can be located to protect individual animals during calving, lambing, or in other situations that threaten losses in unexpected blizzards. The V-shaped wind screen (Jairell and Schmidt, 1988) can be hauled in a pickup truck, and set up by one person in blizzard conditions. The shelter is stable in strong winds and affords excellent downwind protection. Two standard steel corral panels 5 ft tall by 8 ft long provide a frame that supports the shelter covering. These rigid panels, weighing 105 pounds each, come equipped with hinges and pins for quick attachment to form a 90-degree "V".

The cover is reinforced plastic tarp cut to fit the frame (5-by-16 ft). Each end of the cover is sandwiched between two 5 ft long 1-by-6 in boards nailed together. One foot from each end of the boards, an eye screw (1/4-by-1-1/4 in) is screwed into the outside edge of the board. The cover is rolled around the boards for storage.

To erect the shelter, the two corral panels are held up and pinned together with the "V" pointing into the wind. The rolled covering is held at one end of the shelter with rubber cords (32 in long) from the eye screws to the vertical cross-member of the panel. After the cover is unrolled on the upwind side, the other end is attached with two more rubber cords. Maximum wind reduction occurs about 15 ft downwind of the "V". The shelter can be set in the open in five minutes by one person in winds less than 30 mph. The shelters remain stable when subjected to wind gusts exceeding 60 mph. However, if the wind enters the "V" shelter from the back, instability and collapse can result. Shelters left unattended should be anchored with rubber cords to 3/4 in reinforcing rods or metal fence posts staked at the end of each panel.

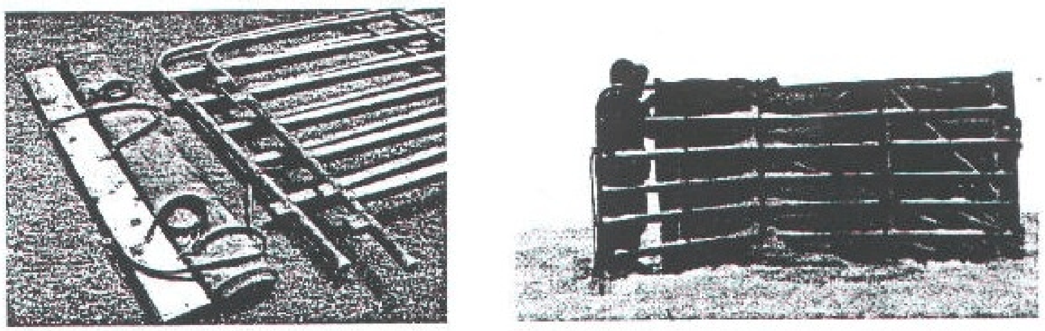

Figure 2. Two corral panels, a tarp, and rubber cords make an effective portable shelter.

Snowdrift Prevention

Snowdrifts can be prevented either by reducing the snow transport that causes the drifts (by inducing deposition behind barriers upwind) or by eliminating the tendency for deposition--allowing the snow to blow by. Snow fences or shelterbelts are the most effective methods for preventing drifts, provided they have sufficient storage capacity. The fastest means of snow control is the snow fence, since shelterbelts take time to grow. To date, the most effective snow-collecting fence is the Wyoming snow fence (Fig. 3). Many other types of snow fence have been investigated, but their trapping efficiency is not as good. The Wyoming snow fence has horizontal boards 6 inches wide separated by a 6-inch space with a gap the bottom of the fence equal to about 10% of fence height. Net porosity (open area) of the structure is about 50% over the total height. The Wyoming fence can be built in heights ranging from 6 ft to 14 ft. A single tall fence is much more effective and economical than a series of shorter fences. Construction costs are less, less space is required, and more blowing snow is intercepted (Tabler 1974). In most western areas of the Great Plains, a fence 9-ft tall is adequate to trap all drifting during a winter with average snowfall.

On large highway systems, costs for materials and labor are as low as $1/ft of fence for each foot of height, or $9/ft for a 9-ft high fence. Costs will be higher for smaller systems. However, compared to the cost of removing snow by machine, snowdrift prevention with snow fences is less expensive by far. The National Research Council (Tabler 1991) estimates average costs for removing snowdrifts by machine is $3/ton. Assuming drifts are 40% water, machine removal costs range from $0.40 to $1 per cubic yard. Preventing drifts by snow fencing costs 3 cents/ton, over the 25-year design life of a properly built, well-maintained snow fence. Not only is prevention 100 times less expensive, its usually lots more convenient.

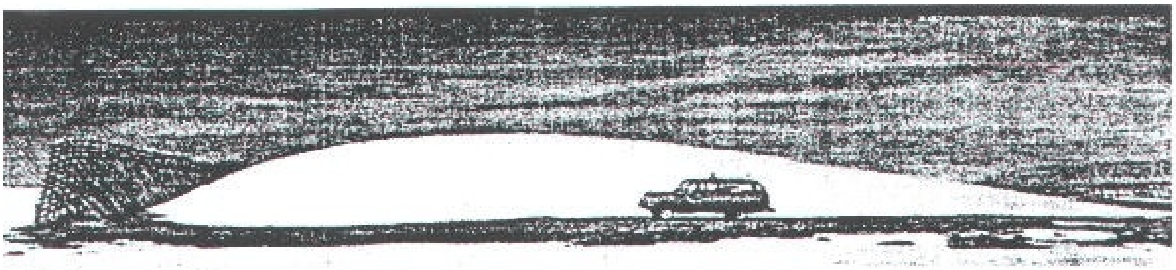

Figure 3. Drift behind 12-ft-tall fence approaching equilibrium shape. Wind is from the left.

Other requirements for successful snow fence protection include:

1. Fences should be sufficiently long to intercept snow with winds varying 25 degrees on either side of the prevailing wind direction. Allowing for 25 degrees accounts for variations in storm direction as well as providing an overlap to compensate for the reduced capacity near the ends of the fence. The required length of a snow fence is, therefore, equal to the sum of the protection width plus the distance between the fence and the downwind end of the protected area. Insufficient overlap is a major cause of poor performance (second only to insufficient capacity).

2. Fences should be continuous, without holes or openings.

3. Fences work best perpendicular to the wind, but departures up to 20 degrees from perpendicular do not significantly reduce storage (Tabler, 1980).

4. A gap of 10-15% of the total fence height should be provided between the bottom of the fence and the ground. "Ground" in this case refers to the top of the local vegetation or anticipated snow cover.

5. Fences should not be placed closer to the protection area than 30 times the fence height to prevent burial. A 9-ft tall fence protecting a driveway, for example, must be at least 270 ft upwind, or the fence will only make the problem worse!

Snow Fencing near Pit Reservoirs to Improve Water Supplies

The primary purpose of developing livestock watering facilities is to provide water where it is scarce, intermittently available, or lacking completely. When a new source of water, or improvements made to increase water in existing ponds is developed in such an area, there is potential for increasing livestock carrying capacity. Sources of water stored in these reservoirs include streams, springs, wells, and in some situations, drifting snow trapped during blizzards. In low-precipitation years, drifting snow may become the main source of water for ponds at windy locations on the High Plains. Drought conditions during 1988-89 in southeastern Wyoming prompted new snow fence construction to capture drifting snow in several reservoirs.

Jairell and Tabler (1985) described small-scale model studies of how interactions between snow fence and embankment locations influence snow deposition in stock ponds. Their recommendations for location of pond embankment and snow fences to accumulate drifting snow, based on model tests, are summarized as follows:

1. Pond embankments (Fig. 4) constructed from excavated fill should be located downwind, not windward, of the pond, (for prevailing blizzard winds).

2. At existing ponds with windward embankments (the customary practice), deposition can be significantly improved by constructing a snow fence along the top of the embankment.

3. Deposition of drifting snow is maximized by locating a snow fence (of 50% porosity) near the windward edge of a pond with the embankment properly located downwind (Fig. 5 left).

Observations of drift deposition in full-scale pit reservoirs (Jairell and Schmidt 1990) confirmed each recommendation based on the small-scale model experiments.

When tree rows were used in place of a snow fence to accumulate snow in a pit reservoir (Fig. 5, right), model studies showed that plantings close to the pond edge improved results (Jairell and Schmidt 1995). If trees were planted at the location recommended as optimum for a snow fence, very little of the drift from the trees was in the pit (Fig. 6).

Other aspects of water supply augmentation with fences, embankments, and surface roughness modifications are discussed in articles by Jairell and Tabler (1985), Jairell and Schmidt (1990), and Sturges and Tabler (1981).

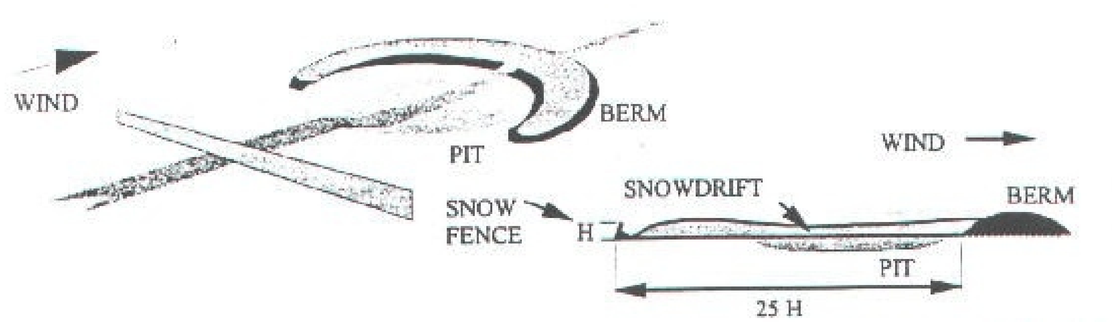

Figure 4. A 1:30 scale model of a pit reservoir 60 ft in diameter, with a 10 ft embankment downwind was a better trap for drifting snow than the same model with the berm upwind (Jairell and Tabler 1985).

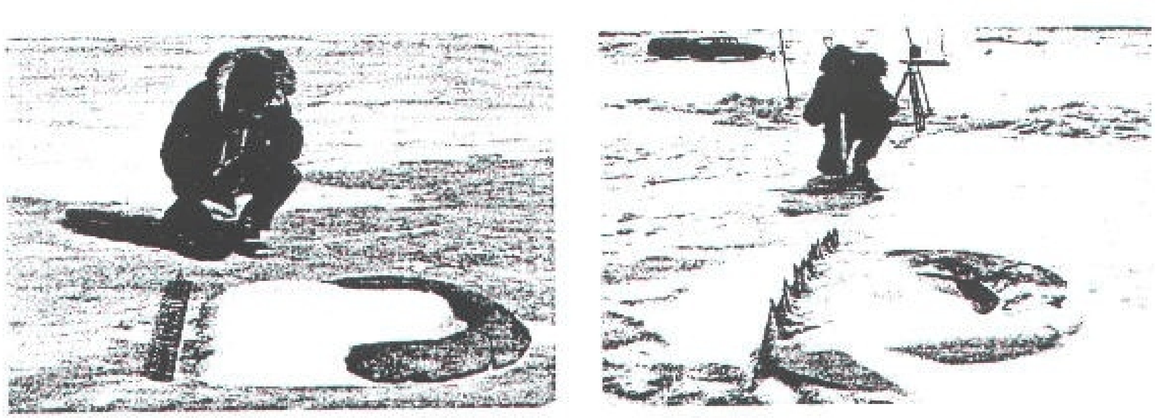

Figure 5. The model stock pond with downwind embankment, comparing snow stored by an upwind snow fence, and by trees on the windward edge of the pond. (Wind from left.)

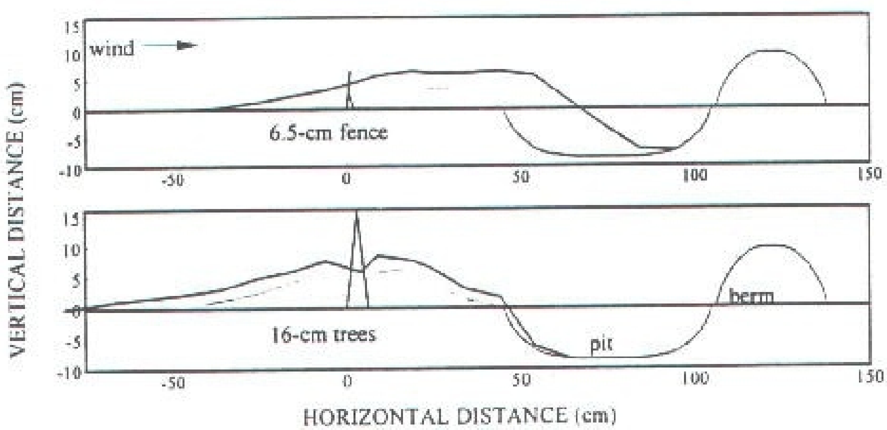

Figure 6. The model results showed that a row of trees put very little drift in the pit unless they were right at the upwind edge (Figure 5). However, the optimum location for a snow fence was 25H upwind of the berm (Figure 4).

Managing Vegetation to Control Drifting Snow

Tall stubble and other methods of retaining snow on croplands have proven cost-effective in the Great Plains, where winter snows provide much of the soil moisture for crop production (Steppuhn and others, 1986). Grass strips in sagebrush (Sturges, 1986) and shrub rows (Laycock and Shoop, 1986) are similar techniques tested on rangelands. Studies have not been extensive enough to develop benefit/cost ratios for rangelands, but these methods accumulate effective snowdrifts.

Although such practices are intended primarily to improve soil moisture for forage, they also provide alternatives to other methods for reducing problems created by drifting snow. For example, if drifts around buildings are a problem, shrub rows or cleared strips in sagebrush in the upwind pastures may greatly reduce such drifts, while improving forage in those pastures. Many of the techniques described for snow drift control are also effective in controlling drifting sand and soil erosion by wind.

Stacking Hay for Protection and Feeding

Where snow blows, hay stacks usually cause drifts that hamper access to the hay, requiring additional time and equipment to clear snow at feeding time. Snow in and around the bales can freeze them together, making removal without breakage difficult and costly.

With our modeling techniques, we looked for solutions, using 2" PVC pipe to build 1:30 scale models that represented 5'x 6' round bales (Figure 7). In light drifting snow, we tried several model arrangements to find one that gave good animal protection with easier bale removal. Tests showed that a "V"-shaped stack without openings provided a drift-free protection area, as long as the distance between the wings was less than 15H. With proper alignment to the wind, access to bales on the ends of the wings was drift-free.

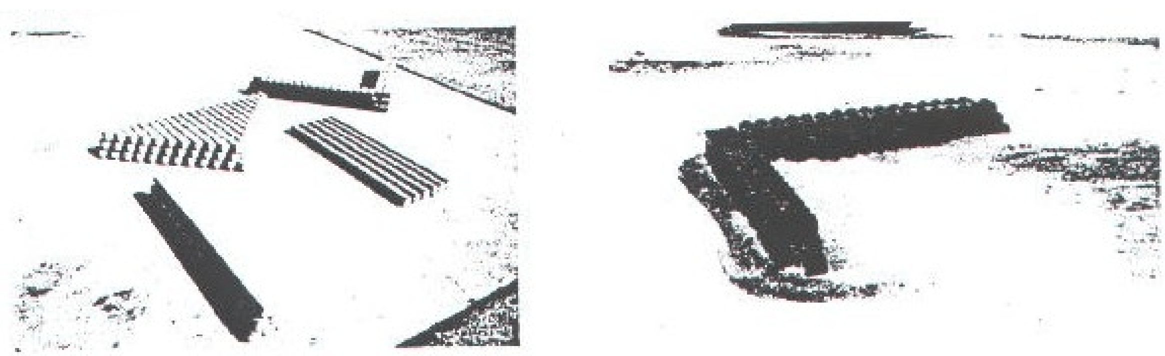

Figure 7. In drifting snow, scale (1:30) models of round bale stacks showed that the rules for protection shelters apply. The stack must be solid (no holes to get drifting through) and the distance between the wings must be less than 15 times the stack height (see Figure 1)

Members of the John E. Rouse Beef Improvement Center near Saratoga, Wyoming conducted full-scale tests of our small-scale model results. Colorado State University (CSU) operates the ranch, which is managed by Mike Moon. Mike built two of these giant hay wedges (Roybal 1999). One was in a river bottom with good natural cover, but with sufficient wind to drift in the usual stack yard. The other test was on a windswept bench where the usual stack yard also drifts in. More importantly, this site provides no natural protection from blizzards that would allow winter feeding of livestock in this pasture.

The layout and geometry of these hay wedges follow the same criteria as building the large permanent animal shelters (Figure 8). Mike stacked the bales two high, for a height of about 12 ft with the bottom row standing vertically and the top row laying horizontally atop them. The two, 125-ft-long wings (50 bales each side) come together to form a 90-degree angle, pointing into the prevailing winter winds, with a distance of 177 ft between the wings. The wedges were then fenced to keep out livestock and wildlife (elk). The fences, 8 ft tall woven wire, follow the shape of the wedges on the upwind side, spaced 5 feet from the bales, with portable panels across the back that can be removed for access to the bales for feeding.

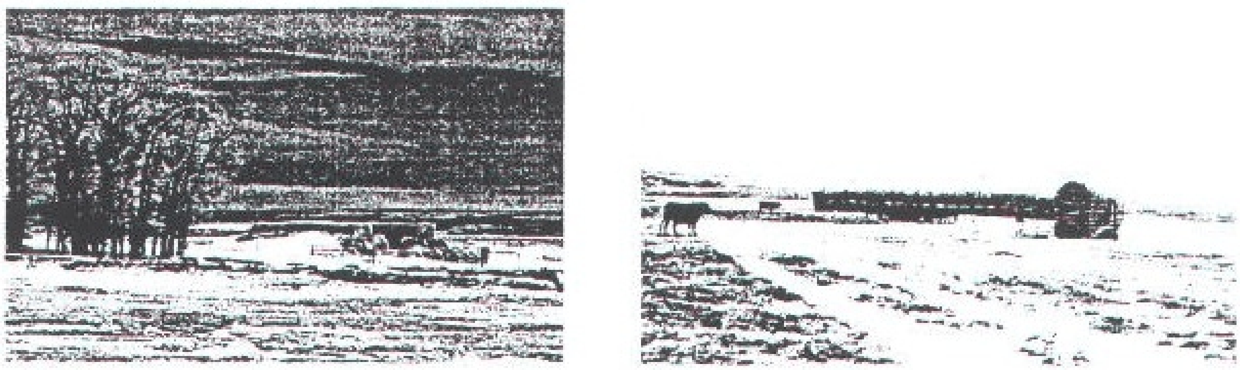

Figure 8. Full-scale tests confirmed the small-scale results. The usual stack yards (left) drifted in, while a nearby hay wedge (right) provided protection (blizzards winds from right) and easier access to the end bales.

There was also an interest in the effects of stacking the hay in a wedge on the quality of the hay. Dr. Doug Hixon, Professor of Animal Sciences with the University of Wyoming, prepared a sampling scheme for monitoring the nutrient value of the hay through the winter season. The usual stack yards, with hay from the same field as the nearby wedge were sampled as the control. For each wedge, Mike took core samples from every third bale, keeping the top row samples separate from the bottom row. At the control stacks, core samples representing the stack yard were saved as one sample. Care was taken to core the same bales at each sample date over a six-month period. It does not appear that the stacking arrangement had any effects on nutrient retention, since energy and protein values appear similar between the wedge samples and controls.

The recommended method for removing bales from the wedges during winter feeding is to remove bales from each end of the wings evenly. This will allow the wedge to continue diverting blowing snow and cold winter winds, while still providing wind protection for livestock.

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