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Experimental Applications of High-Tensile Wire and Other Fencing to Control Big Game Damage in Northwest Colorado

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Abstract.--Conventional fencing methods V-mesh wire, square mesh wire and wood panels are compared to experimental methods - 15 wire hightensile wire fences; electric high-tensile wire fences of three designs; baited electric fences; hog panel fences; plastic mesh fences and visqueen wrapped haystacks. Total cost of materials, cost per ft./yr. and comments concerning estimates of efficacy are discussed. The V-mesh wire, hog panel and plastic mesh fences all have a very high cost per ft. and cost per ft./yr. rating and should probably not be used. High-tensile and square mesh wire fences are effective and cheaper alternatives. Modern high-tensile wire electric fences can be an effective alternatives in some situations. Results from tests using visqueen wrapped haystacks and baited electric fences are encouraging and more experimentation is needed. Wood panels should only be used as an emergency game damage prevention method.

INTRODUCTION

The Colorado Division of Wildlife (CDOW) has statutory responsibility for big game damage to growing crops, orchards, nurseries, fences, harvested crops and livestock forage. Most years the CDOW spends over $1,000,000 per year for game damage prevention materials and claims. From 1979 - 1988, CDOW personnel in Northwest Colorado experimented with various prevention methods to prevent mule deer odo coileus heminous) and elk (Cervus elaphus) damage to haystacks; nurseries and orchards; livestock feedlots and ensilage pits. These experiments were conducted as management experiments opposed to scientific controlled experiments. The evaluation of each of the treatments involved the perception of efficacy by the cooperating landowners and the author. The cost per foot of the fencing is discussed for each type of treatment as well as the life expectancy for the fence and the cost per ft./yr.(the cost of the materials divided by the life expectancy). All costs are based on the estimated cost to build 40 rods of the fence (660 ft.). These costs include all materials, including the staples and tie wires etc., but do not include cost of labor. The cost of materials are based on the retail price in Colorado for the spring of 1989. The experimental methods are compared to the conventional method of **damage** prevention fencing using V-mesh, square-mesh and wood panels. The material list and costs for each method are summarized in table 1.

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METHODS & RESULTS

Conventional Methods

The following **fencing methods are the** primary methods **that are currently being use(** to control most of **the deer and elk damage ij** Northwest Colorado.

Table 1.-- List of items; cost per package unit; number of each item needed; total cost; cost per ft. and cost ft./yr. to build 40 rods (660 ft.) of each type of fence. All costs are retail except for wood panels.

ITEM	PKG. UNIT	PKG. COST	SINGLE U MIT	SINGLE UNIT COST	V-MESH FENCE cry	V-MESH FENCE TOTAL COST	SQUARE MESH FENCE QTY	SQUARE MESH FENCE TOTAL COST	15 HIRE HI TENSIL cry	15 HIRE HI TENSIL TOTAL COST	9 HIRE ELEC III TENSIL 1!V	9 HIRE ELEC III TENSIL TOTAL COST	X00_ ELEC FENCE H/O Cry	X00_ ELEC FENCE EXIST. TOTAL COST
Charger. fence. 110 volt CI 25 kn.>	5165.00 va. 5165_000 "										i $165.00 - 1	-5165.00		
Clamp, fiberglass T post 50/BOX		$2.25 ea.	$0.095								72	$3.21	25	51.13
Clips, dropper	1.000/bor	$25.00		$0.025					2610	$65.25				
Clips, hog ring	100/box	S2_50	_	SO-025			165	59.13						
Dropper . fence stays	va_	S2.50		52.50					171	5935_00				
Fencings Tenser plastic nosh. 7 in κ i69 ft.	roll	5285.00	left-	51.738										
Fleshing. galvanized steel. 19 in_ x 50 ft.	roll	539.73	5.6 v	50.192										
Insulating tuba	100 ft/roll	512.00	1 ft- n	50.120							20	$2.90	12	$1_91
Penal, wood, 8 it. x 8 ft.		519.00		519.000										
Panels, neta1 Chog>, 6 ft. r 12 ft.		525.00	ea_	525.000										
Post, LO ft_ steal		59_59	ea.	59.590			90	5183.60						
Post. 12 ft-, rood, 5 in. top		510.07		$10.870	61	5663.07	21	$228.27	35	5380.95	13	5191.31	10	5108.70
post, 6 ft. steel	ea.	52.53	ea.	52.530									33	983.99
Vest, fiberglass, 10 ft.		56.50		$6.500							9	558.50	5	$32.50
Post. rood. 7 ft. . 5 in. top	ea.	$2.75	es.	52.750										
Rod, grounding, 8 ft. with clamp		$6.95		56.950							1	$6_95	1	56.95
Rods, steel. 1/2 i r T ft.		53_00		53.00										
Sleeves, high tonsil wire ringing. FW 2-3	100/bor	513.50		$0.135					99	$12.69	SO	56.75	32	51.32
Spike, 3/9 in–X 12 in. 50 lbs./box	133/box		532.20	$0.299	6	SI-16	6	S1-96	6			51.96	6	51.96 6 51.16
Spring, Tension indicator	ea.	51.50		59.500					1	51_50	1	51_50	1	59.50
Staple, 2 i sulated	200/box	538.00		50.190							35	$6.65	12	52.28
Staples. 2 i .galvanized, 50 lbs./box	2150/box	523.90		SO.O10	980	59.88	168	$1.60	965	59.65	27	50.27	29	$0.29
Strainer, high tonsil r	oa.	52.75		52.750					IS	591.25	8	522.00	5	513.76
Tritch Stick. 1 in. κ lei . X 98 in., Oak		51.50		51.500	9	56.00	9	56.00	1	56.00	9	56_00	9	56.00
Viaqueen, black, 10 ft. r n100 it., n6 nil	ft.	597.08	ft.	50.•71										

ITEM	PKG_ UNIT	FENCE N/ EXIST_ 0r1	TORN CoSr	FENCE QTLY	FENCE TOTAL COST	FENCE cry	FENCE TOTAL COST	FENCE cry	FENCE TOTAL COST	FENCE cry	FENCE TOTAL COST	FENCE Cry	FENCE TOTAL COST
Charger, fence, 110 volt CI-25 kn_)	ea.	15	165.10	1	$165.00								
Clamp, fiberglass T post	SOlbox	25	51.13	8	50.36								
Clips, dropper	1,000/box												
Clips, hog ring	100/box												
=a pp.,.. f-. st.,9~													
".g. Tenser, plastic mesh, n % 169 7t. roll						66	051.197.08						
Flashing. gel-nized steel. 19 an. x 50 ft.	roll			22	53.12								
Ins~leting tube	100 ft/, .11	12	51.49	9	50.18								
Papal, rood, 9 ft. x 8 ft.	-												
Pane15, metal hog>, 6 ft. x 12 ft-												88	51,232.00
Post, 10 it. steal	-							57	51.925.00				
Post, 12 ft., ood. 5 in. top		10	5108.711			61	5663.07	58	SSW,%				
Post, 6 f t_ steel	aa.												
Post, fiberglass, 1G ft.	ea.	5	S32.;0	9	526.00								
Post, ood, 7 ft. x 5 i . top				2	$5.50								
Rod, grounding, 8 ft. with clamp		1	56.35	1	$6.95								
Rods, steal, 1/2 i x 7 ft.						3	S9.0p						
Sleeves, high tonsil rive c anping, FN 2-3	100/box	32	51.72	9	50.59								
'pill;"" i . % 12 i , SOrlbs_lbox	133lbor	6	S1.*6			6	$1.76						
SprinTensaon indicator		I	59.50										
Staple, 2 i sulated	2001boH	12	52.,8										
Staples, 2 in. ,agal anized. 55.80	50 lbs./box	2.950	1bux 10			$0.10	988	59.88	580				
Strainer. high tonsil u		5	513-TS	1	52.75								
Tritch Stick, 1 i _ X lei . X 99 a . Oak		9	56.iG			9	56.00						
Visqoe , black, 10 ft. xn100 it.,r~6 pa1	it.												
Mir.32 i sgoa ash % 330 ft	-oll									660	5310.86		

V-Mesh Wire Fence

The V-mesh wire fences have been used primarily to control damage to haystacks and ensilage pits. This technique is seldom used on orchards or nurseries because of the high cost of materials and the difficulty of erecting the fencing. The first V-mesh wire haystack fences were installed during the early 1960 's.

The V-mesh wire fence is constructed using 12-ft. wood posts set at 12 ft. intervals and double "H-braces" are used for spans that are in excess of approximately 200 ft. (fig. 1). All corner posts are set 4 ft. in the ground and line posts are set a minimum of 3 ft. Sometimes, 10-ft. steel posts will be used in lieu of a wood line posts as a cost saving measure. Using more than one steel post between each set of wood posts is not advisable if elk damage is anticipated. The V-mesh wire comes in heights of 42 in. to 96 in. The 72-in. fencing has been the most commonly used. The completed fence is 8 ft. high. When the 72-in. fencing is used, there is a strand of barbed wire 6 in. off the ground and two strands on top of the V-mesh wire. This fence is extremely strong and will stand up under heavy elk pressure and the effects of snow. However, this fence is difficult to build because of the heavy wire.

Using all 12-ft. treated wood posts and 72-in. V-mesh wire with three strands of barbed wire, the fence costs $3.08 per foot. The fence should last 30 years and would cost $0.10 per ft./yr.

Square-Mesh Wire Fence

The square-mesh or field wire fence has been used primarily to control damage to orchards and nurseries. The fence is considerably lighter then the V-mesh wire fence and is easier to erect. The CDOW first constructed fences of this type in the late 1950's.

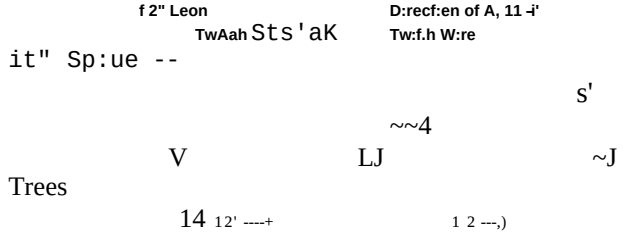

Figure 1.--Construction of a double braced H-brace showing the twitch sticks, twitch wire and brace spike.

The square mesh wire fence is constructed using double braced 12-ft. wood corner posts with line post spaced 12 ft. apart. There are 4 10-ft. steel line posts for every 12-ft. treated wood line post. All corner posts are set 4 ft. in the ground and wood line posts are set a minimum of 3 ft. All steel posts are driven 2 ft. into the ground. Two width of square-mesh wire fencing are used to construct the fence; 47-in. fencing is used on the bottom and 32-in. fencing is overlapped onto the 47-in. fence on the top. The two fences are then joined every 4 ft. with a hog ring. The fence is topped off with 2 strands of barbed wire to make it 8 ft. high. The fence will not stand a lot of pressure from elk. However, by keeping the closest trees or hay at least 10-12 ft. away from the fence, crowding and destruction of the fence by elk should not be a problem. This fence design has proven to be effective in controlling deer damage (Craven 1980, Caslick and Decker 1979).

The fence materials cost $1.18 per ft.. The fence should last a minimum of 30 years and would cost $0.04 per ft./yr.

Wood Panels

Wood panels are made from 18 boards l 1 in. x 4 in. x 8 ft.) of rough cut lumber. There are 14 vertical boards with 4 horizontal boards nailed to them. Panels were originally intended as emergency haystack damage prevention materials. However, over the years some ranchers and CDOW personnel have viewed the panels as the main method for control of haystack damage problems. Many ranchers are lessees and have refused to erect permanent fencing since they aren't sure how long they would be on the land. Other ranchers like to move their haystacks around each year or don't want a permanent fence in the middle of their hay meadow. One of the big problems with wood panels is their short life expectancy. Some ranches are supplied panels almost every year yet they always seem to need more. Other landowners have used panels for unauthorized purposes such as corrals, roping arenas and stock fences. Some ranchers have thrown panels away or burned them rather than try and replace a few broken boards or loose nails.

Presently, wood panels are being built by the Colorado state prison system at a cost of $14.00 each. This doesn't include transportation costs. The cost per foot is $1.87. Panels rarely last over 5 years, thus the cost per ft./yr. is approximately $0.37.

Experimental Methods

The following are some of the experimental methods of deer and elk damage prevention that have been tried in Northwest Colorado.

Fifteen Wire Non-Electric High-Tensile Wire Fence

High-tensile wire fence systems were first developed in New Zealand over 40 years ago. It has numerous application to game damage control (USS 1980). The CDOW has used this type of fence around haystacks and ensilage pits. The fence is constructed using 12-ft. treated wood line posts that are set every 25 ft. Double braced corner posts are set 4 ft. in the ground and secured with a triple strand of smooth twitch wires and twitch sticks (fig. 1). Corner braces are set to lean 2 in. out of plumb and away from the direction of pull. The proper construction of the "H-brace" corners are critical factors in building high-tensile wire fences since the fifteen wire can exert over almost 2 tons of pull on the posts. If the ground is soft or noncohesive *then the* corner posts should be set in concrete or triple braced or both. The high-tensile wires are spaced at varying intervals (fig. 2). The completed fence is 8 ft. high and contains 15 wires. Every 5 ft. a fence stay or d-opper is installed. These prevent the wire from separating and allowing big game animals to penetrate the fence.

The high-tensile wire is installed in the following manner. Each individual strand of wire is first laid out along the fence. Next, the wire is attached to the corner post by wrapping it around the corner or gate post and crimping the end back upon itself with at least 2 crimping sleeves. The wires are then cut in the middle of each strand and an in-line fence strainer is installed on the wire using crimping sleeves to close the splice. Each wire is then slightly tightened to remove the slack. Then each wire is stapled to the fence posts. It is best to use 2 in. galvanized fence staples. It is important not to drive the staples tight against the wire. The wire should be able to slide freely back and forth between the staple and the post. After all the wires have been stapled, then each wire is tightened to 250 lbs. of tension. A tension indicator spring should be installed to determine the proper tension on at least one of the wires. It acts as a calibration tool to adjust the proper tension for the remaining wires. The final step involves installing the fence stays or droppers every 5 ft. using wire clips (fig. 2). Stays can

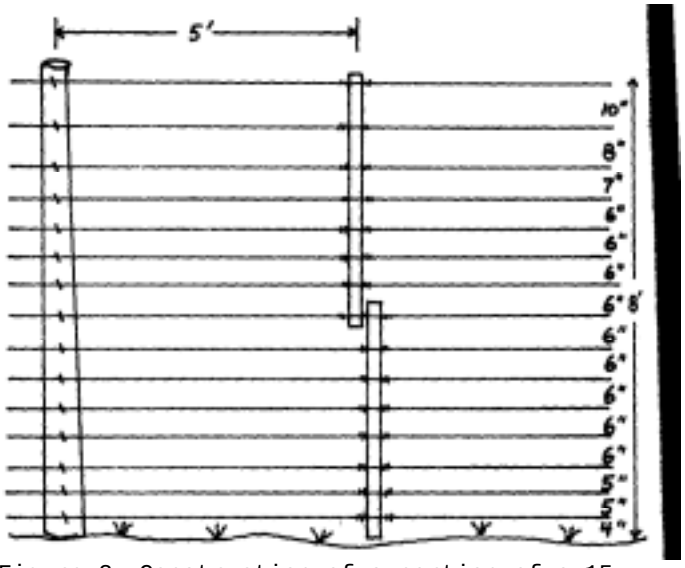

Figure 2--Construction of a portion of a 15 wire high-tensile wire fence showing t) wire spacing. The wood posts are space 25 ft. apart with 4 sets of stays *between each* set of wood posts.

be fiberglass or treated wood. The complete fence should be re-adjusted periodically to maintain the tension. The fence can become too tight in the winter or too loose in the summer. Also, the corner post can settle over time. Re-tightening the fence is as simple as adjusting the in-line fence strainers with a wrench.

The completed high-tensile wire fence is extremely strong and resistant to damage by big game and livestock or even the effects of deep snow. If the fence does become loose, it is a very simple task to re-tighten. The breaking strength of USS Max-Ten 200 hightensile wire is 1815 lbs., almost twice that of conventional barbed-wire (950 lbs.). This brand of high-tensile wire is type III galvanized so it should last in excess of 50' years in dry climates and still retain 50% or more of its original diameter (USS 1980).

The fifteen wire high-tensile fence costs $1.73 per ft. to build. The fence should last a minimum of 40 years and would cost $0.04 per ft./yr. The maintenance cost of this fence should be very low.

Eight Strand Electric High-Tensile Wire Fence

Several of these experimental fences have been built to control game damage to orchards, nurseries and livestock feedlots. This fence has also been used to **fence haystacks, but it may not be practical under most situations because of lack of AC**

electricity or the cost of amortizing a solar or battery powered fence charger over a small stackyard fence. This fence is designed to exclude most big game after they have been aversion trained by the fence. The fence is fairly inexpensive to build **but may** not be 100% effective.

The fence is constructed similar to the 15 wire fence above except that the post for this fence can be spaced about 50 - 150 ft. apart. Also, cheaper and easier to install, 10-ft. fiberglass post can be used as line posts. However, it's recommended to set a 12ft. treated wood post at least every 300 ft. The other main difference is that the fence uses alternating negative and positive wires and no fence stays (fig. 3). All the positive wires must be insulated by using insulated staples, tube insulation or fiberglass line posts. The negative wires need to be well grounded with at least 1 6ft. galvanized steel *grounding rod* for every 1,500 ft. of fence in dry soil and 3,000 ft. in wet soil (USS 1980). All the positive and all the negative wires are interconnected into a negative and positive electric grid. The positive wires are connected to an electric fence charger that can be powered by AC or DC current. Direct current models can be powered by a battery or a battery/solar charger. The new type fence chargers that are currently available from New Zealand or United States should be used. These can provide over 5,000 volts of shocking power and have a low impedance. The wires should be maintained at the same tension as the nonelectric fence (250 Ibs.). In theory, animals will attempt to jump between the wires rather then jump over the fence. By doing so, they are subjected to a very high voltage shock. Hopefully, the experience will

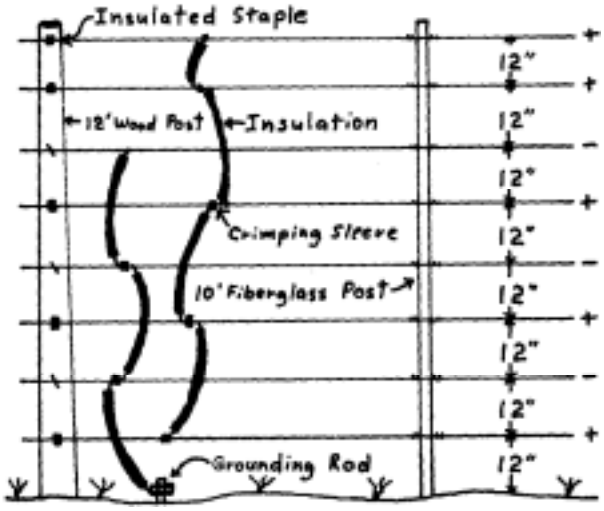

Figure 3--Construction of a portion of an 8 wire high-tensile wire electric fence showing the wire spacing and interconnecting of positive and negative wires.

deter them from entering the fenced area again. The 8-ft. fence should prevent most deer and elk from jumping over the fence. It is important to use the alternating negative and positive wires so that the animal will always be in contact with the ground wire and receive a strong shock even when they are standing on snow covered ground or while they are in mid-air jumping through the fence. These new type electric fences are far superior to the old style and should work much better then the electric fences that Tierson (1969) experimented with to control deer damage.

The cost of the fence using fiberglass line posts spaced at 100 ft. is $0.81 per ft.. This includes the AC fence charger. The fence should last a minimum of 40 years although the fence charger may have to be replaced. The cost per ft./yr. is $0.02. The cost of electricity is additional. U. S. Steel (1980) estimates it would cost $1.00 per month where electricity costs $0.08/kilowatt hour.

Modified Electric High-Tensile Wire Fence

This type of fence is used primarily for orchards and nurseries where an existing square-mesh wire fence is already in place. However, the fence can be constructed from scratch. It provides a very dependable fence against livestock, big game and even small mammals. The electric high-tensile fence is actually constructed on top of the existing fence (fig. 4). The existing corner and gate posts have to be removed and new 12-ft. treated wood posts installed. These posts should be set to the same specification as the double "H-brace" (fig. 1). Next, 10-ft. fiberglass posts are set every 50-150 ft. along the fence. A 12-ft. treated wood posts should be set every

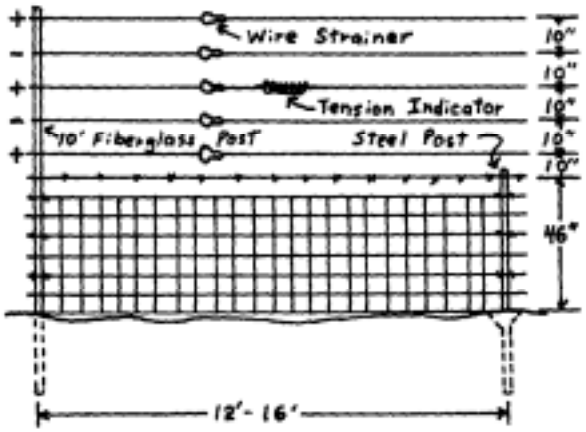

Figure 4--Construction of a portion of a modified high-tensile wire electric fence

fence solid. The bottom portion of the fence consists of the existing square-mesh wire fence, usually 32-47 in. high with 1 or 2 strands of barbed wire on top, set on wood or steel line posts. The upper, or new portion of the fence, consists of alternating positive and negative high-tensile wires. The wires are installed exactly like the electric fence described above (fig. 3). The first high-tensile wire above the old fence should be electric and the top wire should be electric with the remaining wire alternating positive and negative. The wires should be spaced approximately 10-12 inches apart and the top wire should be 8 ft. above the ground. Care should be taken not to allow the first electric wire to sag and contact the existing barbed wire or steel posts. The fence provides a very reliable barrier to prevent livestock and possibly some small game and varmints from penetrating the bottom portion of the fence. The upper portion of the fence can provide a barrier to deer and elk that may try to jump through or over the electric fence wires. This fence can be penetrated by big game, but in theory the experience should be very unpleasant and should deter future penetrations. This fence has the advantage over the all electric hightensile fence by being at least partially functional at all times and should always deter livestock even when the electricity is turned off. Also, one of the big disadvantages of an all electric fence is vegetation will sometimes ground out the fence. This should not be as big of problem with this fence.

Depending on whether or not there is an existing fence, the cost can vary from $0.64 per ft. with an existing fence to $1.02 per ft. for an all new fence. The entire fence should last a minimum of 35 years. The cost per ft./yr. is $0.02 when there is an existing fence and $0.03 per ft./yr. without an existing fence.

Baited Electric Fence

Kinsey (1976) described using a single strand electric fence, 1 m. above the ground, baited with peanut butter on aluminum foil flags to repel white-tailed deer (Odocoileus virginianus). Porter (1983) found this technique to be very effective in reducing white-tailed deer damage to young apple trees in New York and felt the deer were repelled by behavioral conditioning. He did not test the fence on large areas (>5 ha). A similar baited electric fence was tried on a small apple orchard in Palisade. A single strand of high-tensile wire was installed 1 m. above the ground. Seven-foot wood posts were set at each corner and a 5-ft. fiberglass post was set every 75 ft. to support Aluminum roofing flashing was used instead aluminum foil to make the flags or pockets that held the peanut butter onto the fence, The flags were placed approximately 30 ft. apart. The fence was in place for approximately three months (February to April). The landowner was lax in maintaini the battery that powered the fence charger, However, fence did appear to be somewhat effective in reducing deer damage in the fenced area. Deer tracks around the perimeter indicated where some deer evidentl came in contact with the wire or flags. These sites contained large amounts of deer hair and torn up ground, indicating a fast retreat. Some deer did cross the fence and continued to browse on the young apple trees. However, the damage did not appeart as severe as prior to the fence.

The cost of the baited fence per footi $0.34. The main cost is the fence charger. Without the charger the fence would only coo $0.09 per ft. With the exception of the fence charger, the fence should last a minimum of 40 years. The cost per ft./yr.ie $0.01. This fence may require a lot of maintenance re-baiting the flags with peanut butter and

Tensar Plastic Fence

One haystack fence using plastic-mesh fence was installed in Oct. 1986 in the Kremmling area. The fencing is manufactured by The Tensar Corporation, Morrow, Ga. The fencing is 7 ft. high and can be installed similar to V-mesh or square-mesh wire. The CDOW installed the fence on 12-ft. treated wood posts spaced 12 ft. apart. The different fence rolls are spliced together by overlapping the two ends and running a galvanized rod down between the two meshes. The advantage of the fence is that it is very easy to install and easy to work with because of the light weight. However, we are concerned that the fence will break down due to weathering. After 2-1/2 years some strands on the corner posts have already separated.

The cost per foot is $2.88. The the f fence should last a minimum of 10 years. Thel cost per ft./yr. is estimated to be $0.29.

Hog Panel Fence

During the past three years, the CDOW has been using commercial hog panel fencing on an experimental basis. The most commonly used panels are 7 ft. by 12 ft. Although the

panels are made in heights up to 7 ft. and widths up to 16 ft. The panels are secured to 12-ft. wood posts, set about 11-1/2 ft. apart, with fence staples and smooth wire. The fences are relatively easy to construct since no corner "H brace" posts are needed or wire stretching. The panels are very rigid and sturdy. They have been very effective in controlling elk damage.

The cost per foot for the completed fence is $3.43. The fence should last a minimum of 40 years for a cost per ft./yr. of $0.09.

Visqueen (Black Plastic) Wrapped Haystacks

As an alternative to wood panels to control damage to haystacks, CDOW personnel have been experimenting with wrapping the haystacks with visqueen. The visqueen is 10 ft. high and has a thickness of 6 mils. The plastic is attached to the haystacks by placing a pebble, approximately 1 in. in diameter, near the top 1 ft. from the edge and folding the edge over and tying a piece of baling twine around the pebble. The loose end of the twine is then secured to the baling twine on the hay bales. The whole haystack is wrapped in visqueen from the ground up to a height of 7-8 ft. The results have been very encouraging so far for both deer and elk. This technique provides a fairly cheap and easy to install alternative to panels or permanent fencing. It is especially useful when deep snow would limit vehicular access to a **haystack making** it difficult to use wood panels.

The cost per foot is $0.47. The life expectancy of this material is one season. Thus, the cost per ft./yr. is $0.47.

CONCLUSIONS

1. The effectiveness, initial cost per ft. and the cost per ft./yr., should all be considered in evaluating a fencing system.

2. V-mesh wire fences, hog panel fences and plastic mesh fences (Tensar - brand name) all have a very high initial cost and cost per ft./yr. It would be wise to consider other alternatives before using these materials for permanent fences. Plastic mesh fences have a cost per ft./yr. that is almost 3 times as much as V-mesh and hog panel fences because of their short life expectancy.

3. Square-mesh wire fences are cheaper to build than 15 wire high-tensile fences ($1.18 vs. $1.73 per ft. respectively). Both, offer about the same degree of effectiveness, but the high-tensile wire fence will probably last longer, thus, both have the same cost per ft./yr. ($0.04).

4. High-tensile wire electric fences such as the 8 wire fence and the modified electric fence both offer a low initial cost per ft. and a low cost per ft./yr. rating. The fences are not completely effective in preventing all damage but offer a cheaper alternative and a long term solution.

5. Electric high-tensile wire fences require more maintenance but may provide a good alternative for preventing severe damage that occurs for only a short period of time during a calendar year, such as heavy winter browsing to nursery stock.

6. The baited electric fence has shown some promise and may be a viable alternative to 8 ft. fencing when the fence will only be needed for a few years, such as when a new orchard is being established in close proximity to a much larger mature orchard. More experimentation is needed.

7. Visqueen (black plastic) can be a cheaper and effective alternative to wood panels to control haystack damage. More experimentation is needed.

8. Because of their short life expectancy and high cost per ft./yr., wood panels should only be used as emergency prevention methods. Permanent fencing using square-mesh or high-tensile wire should be used to solve continuing problems because they cost about 80-90% less over their life expectancy.

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