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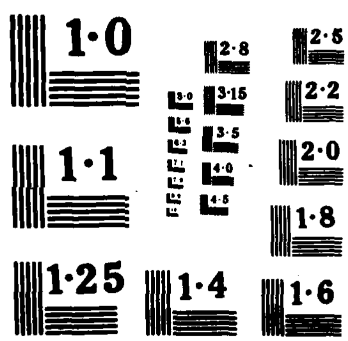
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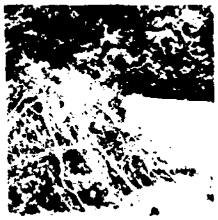

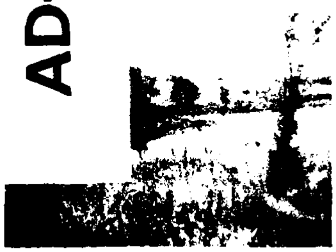

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ENVIRONMENTAL IMPACT RESEARCH PROGRAM

TECHNICAL REPORT EL-86-7

IMPASSABLE WIRE FENCES

Section 5.2.3, US ARMY CORPS OF ENGINEERS WILDLIFE RESOURCES MANAGEMENT MANUAL

by

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US ARMY ENGINEER WATERWAYS EXPERIMENT STATION

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Slanting fences
(Continued)

19 ABSTRACT *(Continue on reverse if necessary and identify by block number)*

A management techniques report on impassable wire fences is provided as Section 5.2.3 of the US Army Corps of Engineers Wildlife Resources Management Manual. The report was prepared as a guide to assist Corps biologists and resource managers in the selection and implementation of impassable wire fence techniques where these fences are required or desirable for wildlife and habitat management programs. Topics covered include description, design and construction, placement, personnel and costs, maintenance, and cautions and limitations.

Impassable wire fences are barriers that restrict wildlife access into areas that are hazardous or where grazing is not desired. They may be required along concrete-lined canals to prevent drowning or maiming of wildlife, and are often needed along highways to prevent large mammals from becoming a hazard to motorists. Impassable fences may also prevent destruction of newly planted habitats, nesting areas, and riparian vegetation. Two
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basic types of impassable fences, upright fences and slanting fences, are described in this report. Details are provided on their design, construction, installation, maintenance, and placement in suitable terrain. Specification drawings and lists of materials required for construction are included.

PREFACE

This work was sponsored by the Office, Chief of Engineers (OCE), US Army, as part of the Environmental Impact Research Program (EIRP), Work Unit 31631, entitled Management of Corps Lands for Wildlife Resource Improvement. The Technical Monitors for the study were Dr. John Bushman and Mr. Earl Eiker, OCE, and Mr. Dave Mathis, Water Resources Support Center.

This report was prepared by Mr. Larry E. Marcy, Department of Wildlife and Fisheries Science, Texas A&M University, College Station, Tex. Mr. Marcy was employed by the Environmental Laboratory (EL), US Army Engineer Waterways Experiment Station (WES), under an Intergovernmental Personnel Act contract with Texas A&M University during the period this report was prepared. Mr. Chester O. Martin, Team Leader, Wildlife Resources Team, Wetlands and Terrestrial Habitat Group (WTHG), EL, was principal investigator for the work unit. Review and comments on the report were provided by Mr. Martin and Dr. Wilma A. Mitchell, WTHG; Mr. Ted B. Doerr, Colorado State University, Fort Collins, Colo.; and Mr. E. Paul Peloquin, US Army Engineer Division, North Pacific, Portland, Oreg.

The report was prepared under the general supervision of Dr. Hanley K. Smith, Chief, WTHG, EL; Dr. Conrad J. Kirby, Chief, Environmental Resources Division, EL; and Dr. John Harrison, Chief, EL. Dr. Roger T. Saucier, WES, was Program Manager, EIRP. The report was edited by Ms. Jessica S. Ruff of the WES Publications and Graphic Arts Division (PGAD). Drawings were prepared by Mr. John R. Harris, Scientific Illustrations Section, PGAD, under the supervision of Mr. Aubrey W. Stephens, Jr.

At the time of publication, COL Allen F. Grum, USA, was Director of WES, and Dr. Robert W. Whalin was Technical Director.

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NOTE TO READER

This report is designated as Section 5.2.3 in Chapter 5 -- MANAGEMENT PRACTICES AND TECHNIQUES, Part 5.2 -- FENCES AND CROSSINGS, of the US ARMY CORPS OF ENGINEERS WILDLIFE RESOURCES MANAGEMENT MANUAL. Each section of the manual is published as a separate Technical Report but is designed for use as a unit of the manual. For best retrieval, this report should be filed according to section number within Chapter 5.

IMPASSABLE WIRE FENCES

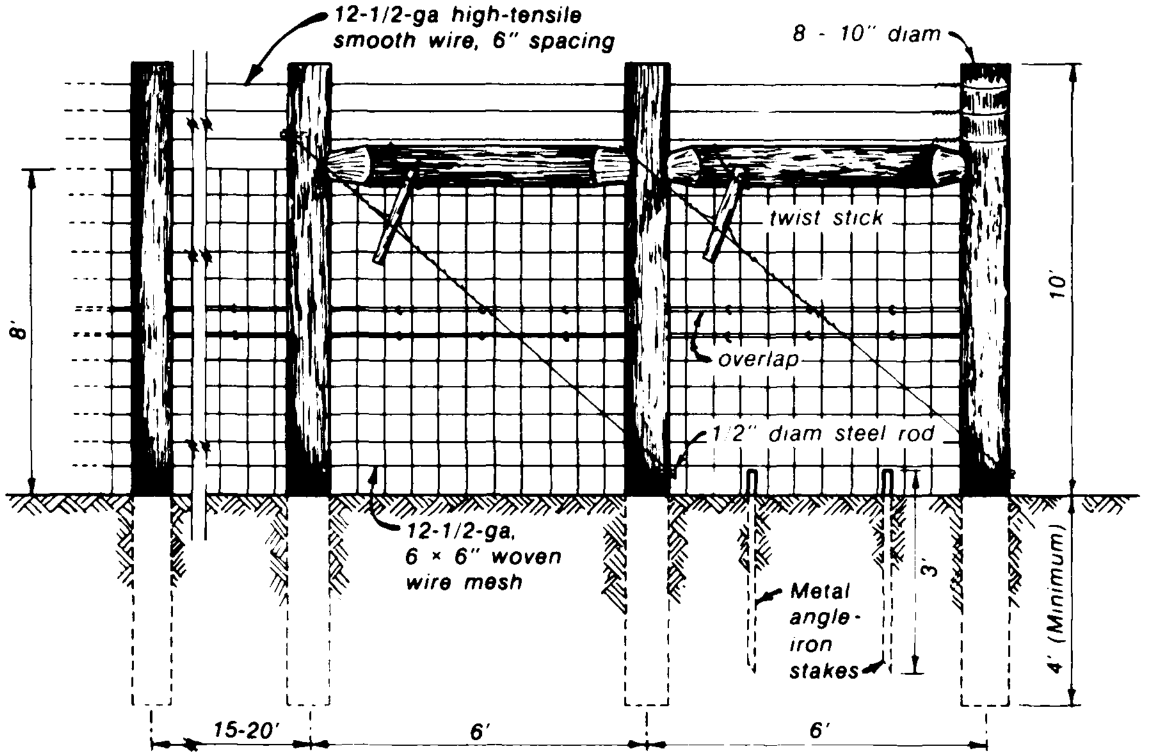
Section 5.2.3, US ARMY CORPS OF ENGINEERS
WILDLIFE RESOURCES MANAGEMENT MANUAL

Impassable wire fences are barriers that restrict wildlife access into areas that are hazardous or where grazing is not desired. They may be required along concrete-lined canals to prevent drowning or maiming of wildlife, especially big-game species (U.S. Fish and Wildlife Service 1978), and are often needed along heavily trafficked highways to prevent large mammals from becoming a hazard to motorists. Impassable fences may also be used to prevent destruction of newly planted habitats, nesting areas, and fragile riparian vegetation. They appear to be most useful and cost effective on small open sites and least useful on large sites with dense vegetation (Wade 1982). Two basic types of impassable fences, upright fences and slanting fences, are described in this account.

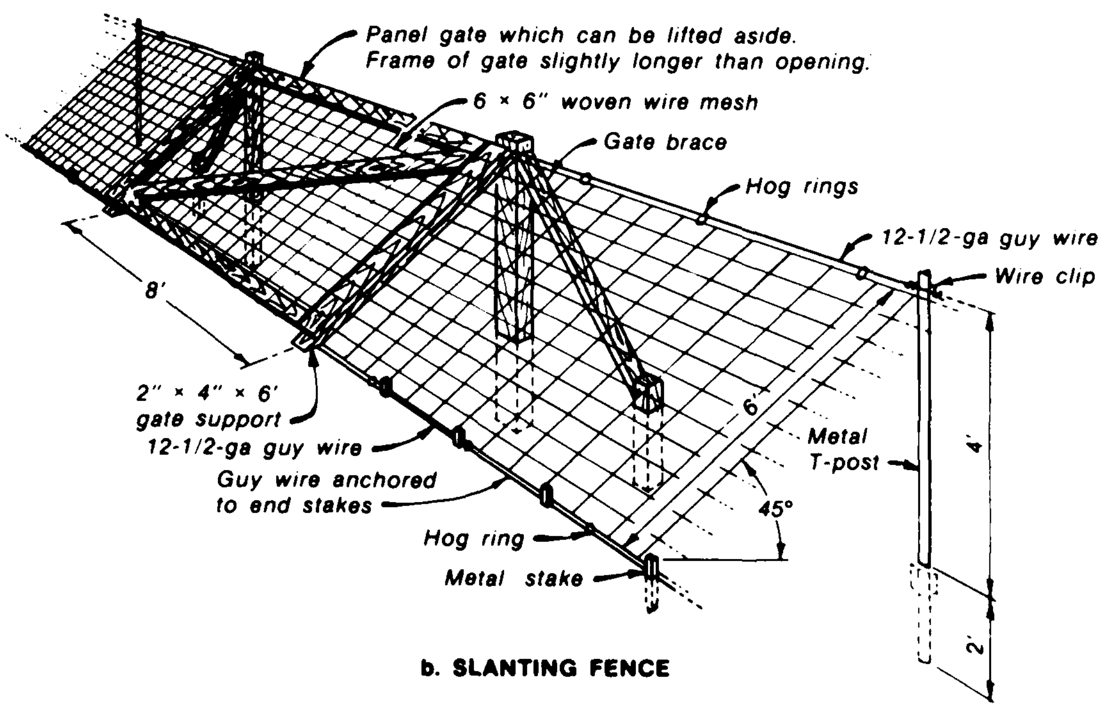
DESCRIPTION

Upright Fence

Upright impassable fencing guidelines follow the general recommendations outlined for conventional fencing except (1) post height is greater, and (2) the type of wire and the spacing between wires are variable (Fig. 1a). Heights of impassable fences vary from 6 to 10 ft, but 7-1/2- to 8-ft fences are more common (U.S. Fish and Wildlife Service 1978). Woven-wire mesh is preferable for the entire height of the fence (Longhurst et al. 1962). Welded-mesh wire is long lasting and less expensive but does not conform well to surface irregularities.



a. UPRIGHT FENCE



b. SLANTING FENCE

Figure 1. Upright woven-wire deer-proof fence (a), and temporary slanting deer-proof fence with gate panel (b) (from Longhurst et al. 1962)

Slanting Fence

An alternative to the upright fence is the slanting deer-proof fence (Fig. 1b). Messner et al. (1973) suggested using this type of fence because it (1) is more economical to build than an upright fence, (2) is pleasing to the eye, and (3) blends into the surrounding scenery better than an 8-ft-tall upright fence. The slanting fence is also suitable for temporary exclosure fencing, as it requires fewer posts than an upright fence, can be easily removed, and the wire can be more readily rolled up (Longhurst et al. 1962). This design is effective because it acts as a physical and psychological barrier to deer. The fence is normally positioned with the high side away from the area to be protected. Deer usually try to crawl under the fence but find this impossible, and jumping is difficult because of the wire extended above them. Blaisdell and Hubbard (1956) suggested that when the slanting fence is positioned with the high side toward the area to be protected, deer cannot approach close enough to the base of the fence to jump over it. The disadvantages of using a slanting fence are that (1) large livestock easily damage the fence, (2) small livestock can push under, (3) weeds growing underneath may render the fence ineffective unless controlled, (4) rough terrain can make construction difficult, and (5) mesh wire may be crushed down by heavy snowfall (Longhurst et al. 1962, Messner et al. 1973).

DESIGN AND CONSTRUCTION

Upright Fence

The typical upright fence consists of 2 spans of woven-wire mesh (each 4 ft tall) topped with 1 to 3 strands of 12-1/2-ga smooth wire supported by wooden or metal posts; the posts are 8 to 10 in. in diam and 12 to 14 ft long on 10- to 12-ft centers. Fences located on sloping ground may need to be 10 to 11 ft high to guard against deer jumping over the fence from the high side. Corner, brace, and line post assembly follow the recommendations given under conventional fence construction. Longhurst et al. (1962) recommended woven-wire mesh with 6- × 6-in. spacings because it conforms readily to ground irregularities. An alternative method is to use 4- × 4-in.-mesh wire on the bottom span and 12- × 12-in.-mesh wire on the top span. Thompson (1979) recommended the use of "rabbit or poultry" wire over the woven-wire mesh from ground level to 6.7 ft high and an apron along the ground (≥15 in. wide) to] prevent animals from crawling under fences. Mesh wire should be secured to the ground with 3-ft-long angle-iron stakes.

A strand of smooth wire can also be stretched tightly along the bottom edge of the lower span for added strength. One to 3 strands of 12-1/2-ga high-tensile smooth wire may be attached above the top span of mesh wire. Wire smaller than 12-1/2-ga is not recommended (Longhurst et al. 1962). Table 1 provides an estimate of the materials needed to build 1 mile of upright deer-proof fence.

Construction of impassable fences across drainage channels should not restrict water flow. If the channel is small, with an intermittent flow, some type of wooden, metal, or concrete culvert is usually best (Longhurst et al. 1962) (Fig. 2). Where there is a large channel with a permanently flowing stream to be spanned, swinging gates in the direction of flow and with the gate bottoms just below the water surface are effective (Fig. 3). All fences that cross streams or drainages should be built with breakaway sections that are securely anchored at one end.

Slanting Fence

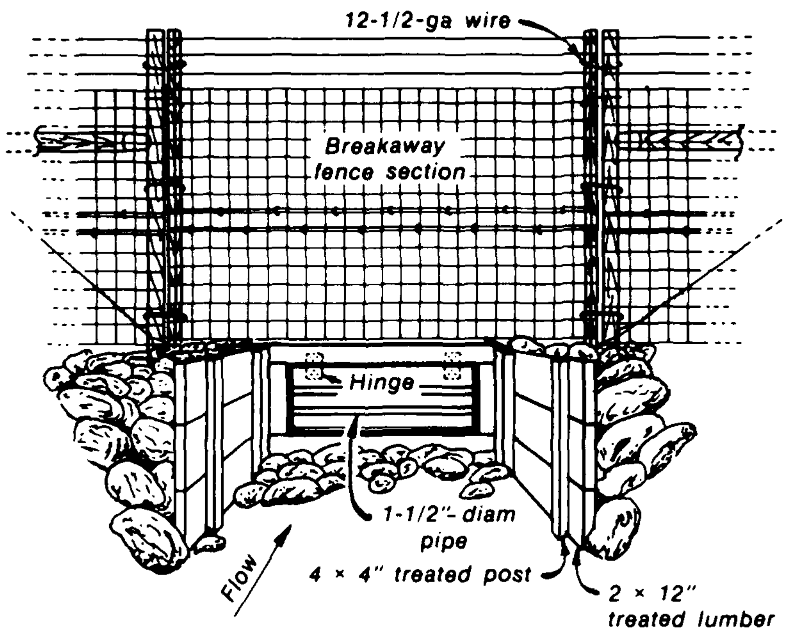
A slanting deer-proof fence is normally constructed with the high side of the fence away from the area to be protected (Longhurst et al. 1962). Materials required to build a 1/3-acre exclosure with slanting fence are listed in Table 2. A temporary slanting fence consists of 6- × 6-in., 12-1/2-ga woven-wire mesh, 6 ft in width, supported by 9-1/2-ga guy wires between widely spaced metal posts (30 to 40 ft apart) (Fig. 1b). Metal T-posts 6 ft tall, set 2 ft in the ground, are recommended. Woven-wire mesh is held in place by metal hog rings attached to the top and bottom guy wires. The bottom edge of the wire mesh should also be attached to the ground with 2-ft-long metal stakes.

In areas of heavy snowfall, 6-in.-diam wooden posts should be used for added strength. This type of slanting fence is more permanent and less subject to damage caused by wildlife and weather (Messner et al. 1973) (Fig. 4). Corners are constructed as described for a conventional fence. In addition, a 45-deg notch is cut in the top of each vertical post to receive the 4- × 4-in. × 7-ft slanting posts and hold them against horizontal stress.

The slanting posts are secured at ground level with a 10-in.-long spike driven into a 4- × 18-in. section of post set approximately 12 in. deep. The

Table 1. Materials needed for 1 mile of upright deer-proof fence

Item	Use	Quantity
Post (treated)		
5-in. diam × 12 ft	Corners and stress points	22
4-in. diam × 12 ft	Line posts and braces	360
6-in. diam × 18 ft	Gates	2
4-in. diam × 9 ft	Braces	4
Lumber (treated)		
2 × 8 in. × 16 ft	Bracing	3
2 × 8 in. × 14 ft	Bracing	1
2 × 4 in. × 10 ft	Bracing	1
Woven wire (galvanized)		
50 in. wide × 10 rods long, 14-1/2-ga, 4 × 4 in. mesh	Lower course	33
47 in. wide × 20 rods long, 12-1/2-ga, 6 × 6 in. mesh	Top course	17
26 in. wide × 20 rods long, 14-1/2-ga, 6 × 6 in. mesh	Horizontal apron	16
32 in. wide × 10 rods long, 12-1/2-ga, 6 × 6 in. mesh	Stream crossing	1
60 in. wide × 150 ft long, 6-ga, 6 × 6 in. mesh	Stream crossing	1
Single-strand wire (galvanized)		
80-rod roll, 12-1/2-ga	Fence top, single strand	5
100-lb roll, 9-ga	Stream crossing and bracing	2
Multiple-strand wire (galvanized)		
60-ft roll, 1/4-in. diam, 7 steel strands	Bracing	1
Wire clamps (U-bolt)		
1/2-in. diam	Join brace wire	10
Wire staples		
1-3/4 in. long	Fasten mesh wire	100
Hog rings		
Large	Joining courses of mesh wire	5000
Nails		
20d	Secure wire	50 lb
40d	Secure wire	50 lb
Gates (galvanized)		
8 × 12 ft	Vehicular access	1
3 × 4 ft	Personnel assess	1



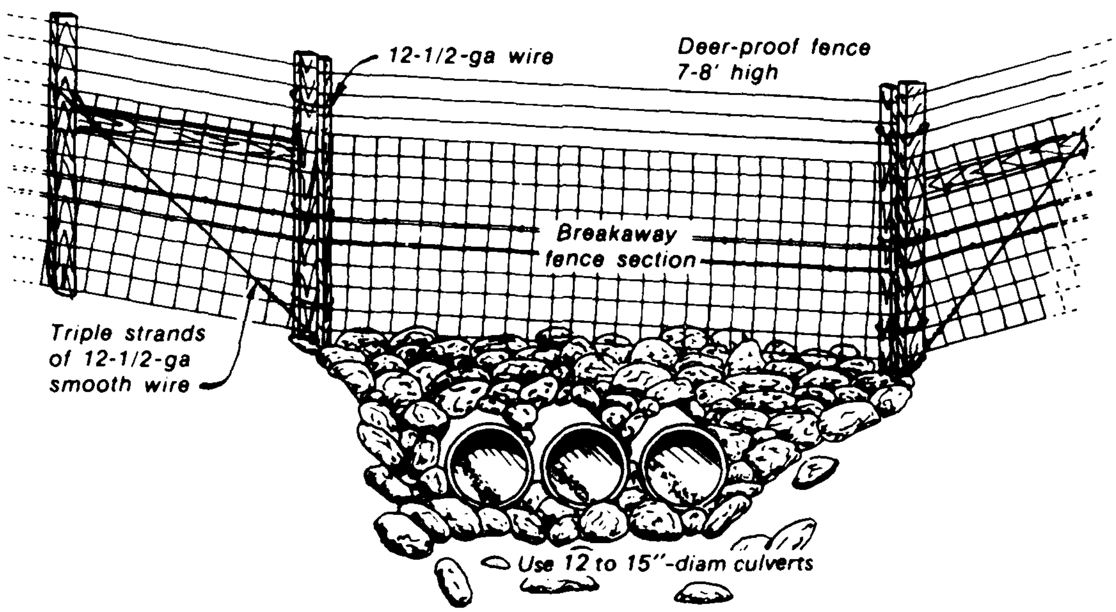
NOTES

One or more 12-to 15" diam culverts or vertical pipes spaced not more than 6" apart may be substituted for swinging gate.

Swinging gate frame made of 2 × 4" treated lumber.

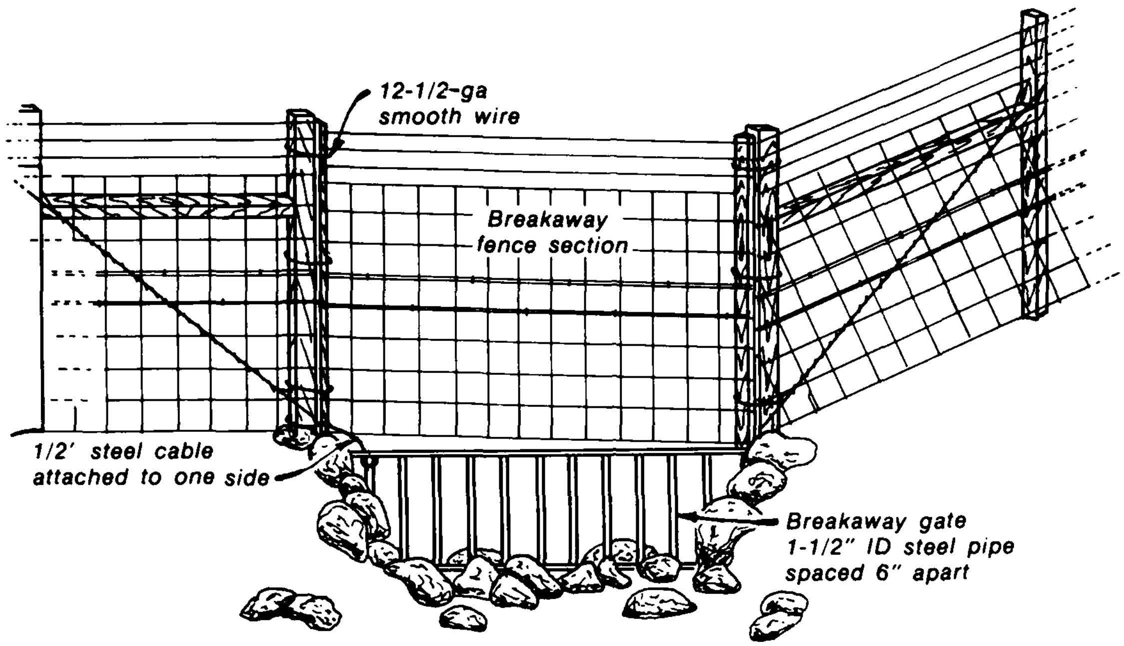
Anchor one side of the breakaway section with 1/2 in. steel cable.

SWINGING GATE DRAINAGE STRUCTURE

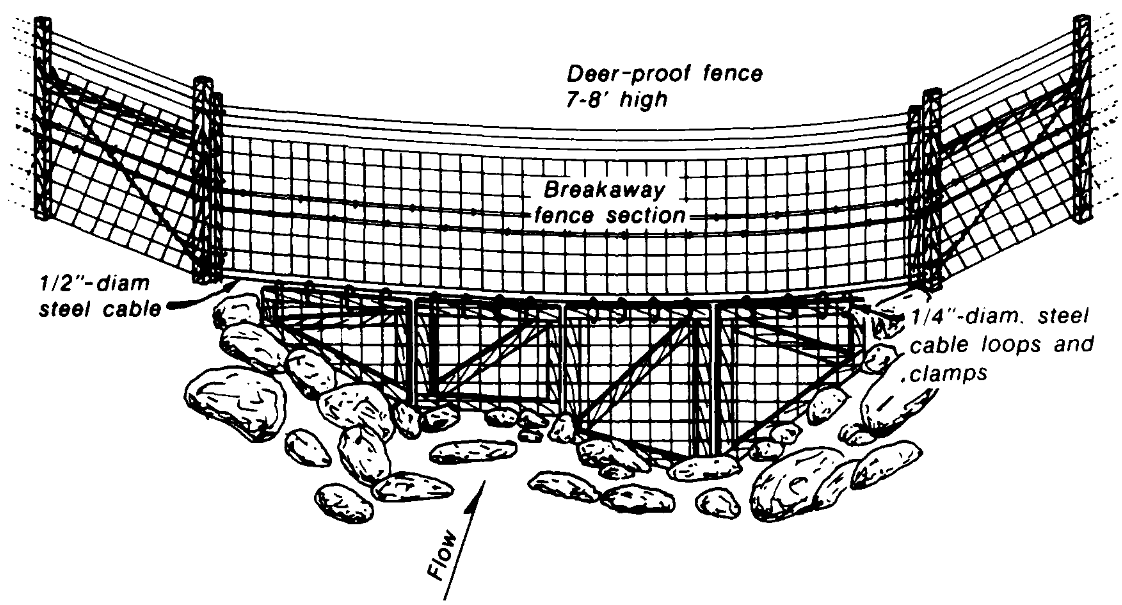


CULVERT TYPE DRAINAGE STRUCTURE

Figure 2. Deer-proof fencing and drainage structures for narrow watergaps (from Longhurst et al. 1962)



VERTICAL PIPE DRAINAGE STRUCTURE



SWINGING GATES FOR A LARGE STREAM

Figure 3. Deer-proof fencing and drainage structures for wide watergaps (from Longhurst et al. 1962)

Table 2. Materials required to enclose a 1/3-acre-square plot (120 × 120 ft) with the modified slanting deer fence (from Messner et al. 1973)

Item	Use	Quantity
Posts (round)		
6-in. diam × 7 ft	Corner	16
4-in. diam × 6 ft	Line and brace	40
4-in. diam × 6 ft	Ground support post	4
Posts (square)		
4-in. diam × 7 ft	Slanting post	48
Wire (galvanized)		
48 in. wide × 20 rods long, 12-1/2-ga, 6- × 6-in. woven mesh	Main course	2
24-in. wide × 150 ft long, 1-in. mesh poultry wire	To exclude small animals at bottom	4
80 rod-roll, 12-1/2-ga smooth wire	Top and bottom support strands	3
Staples		
1-3/4 in. long	Fasten wire mesh to posts	20 lb
Hog rings		
Large	Fasten wire mesh to smooth wire	1000
Nails		
10-in. spikes (40d)	Fasten posts together	80

top edge of this short post should also have a 45-deg notch to receive the bottom end of the slanting post. The top end of the slanting post is secured with 8-in.-long spikes.

Fence wires are attached from ground level up to the top of the slanting posts in the following manner:

(1) Staple 4 strands of 12-1/2-ga smooth wire 6 in. apart to the posts.

(2) Place 24-in.-wide, 1- × 1-in. poultry wire mesh over the 4 strands of smooth wire and fasten with hog rings.

(3) Place 48-in.-wide, 6- × 6-in. woven-wire mesh above the poultry wire and staple it to the posts.

(4) Fasten the bottom edge of the woven-wire mesh to the smooth wire strand with hog rings.

(5) Staple 3 strands of 12-1/2-ga smooth wire 6 in. apart above the woven-wire mesh.

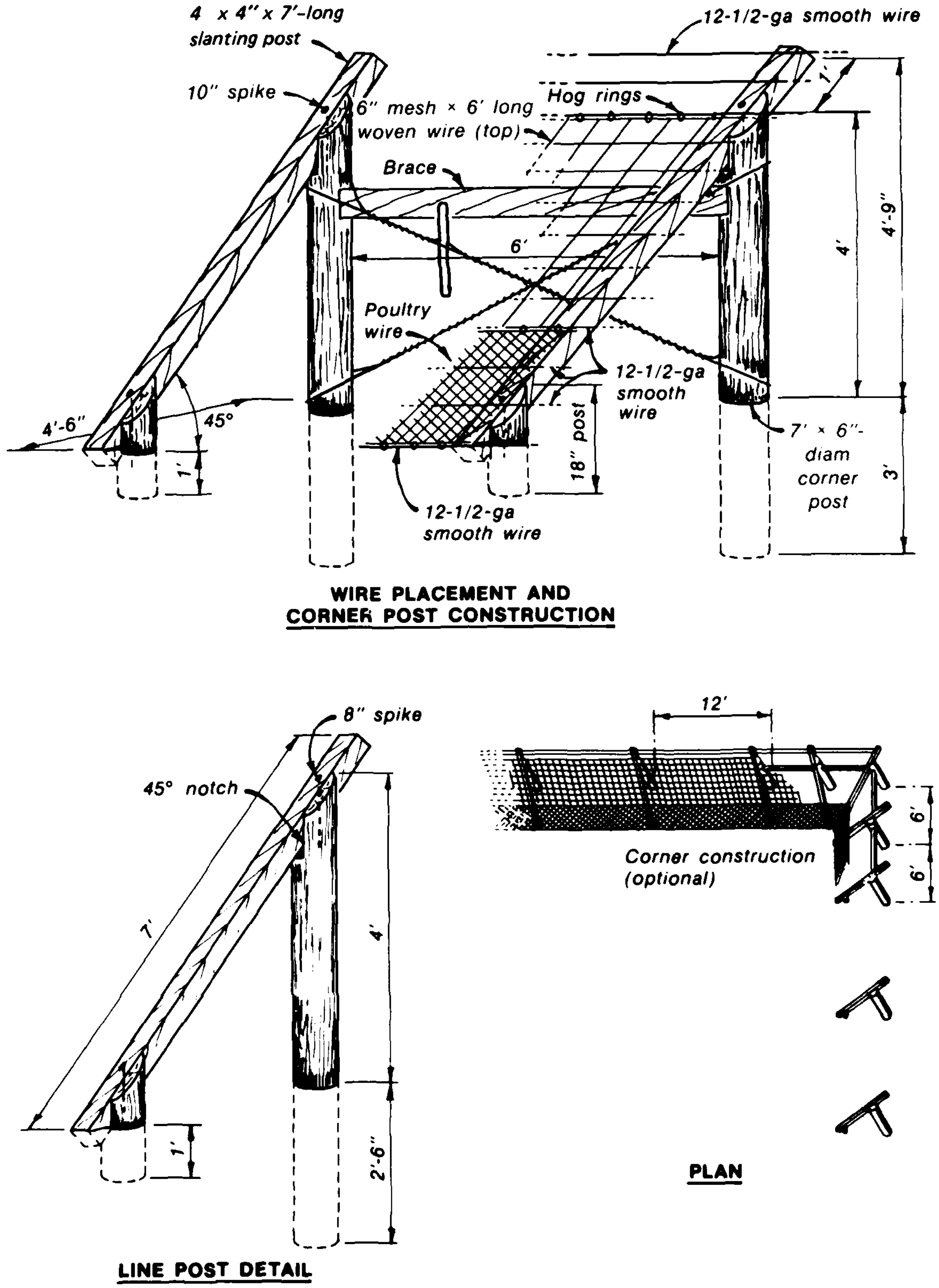


Figure 4. A permanent slanting deer-proof fence showing (a) construction details, (b) line post detail, and (c) overhead plan view of post placement for corners (modified from Messner et al. 1973)

(6) Fasten the top edge of the woven-wire mesh to one strand of the smooth wire with hog rings.

Where 2 fence corners meet, a pie-shaped wedge of woven-wire mesh and several strands of smooth wire can be used to close the opening. For added strength, a corner brace and slanting post can be set to support the fence wire at the junction of 2 corners (Fig. 4). The corner slanting post should be approximately 10 ft long for this application.

An alternative type of slanting deer-proof fence is a 4-1/2-ft upright metal fence with an 8-ft-wide extension sloping from the top of the fence to the ground (Blaisdell and Hubbard 1956) (Fig. 5). The fence is positioned with the high side toward the area to be protected; deer cannot approach close enough to jump over. Construction of the upright portion of the fence consists of 12-1/2-ga, 2- × 4-in. wire mesh, 6 ft wide, suspended on 7-ft metal posts that are installed 12 ft apart. An 18-in. section of the wire mesh is buried in a trench, and the remaining 54-in. section above ground is attached

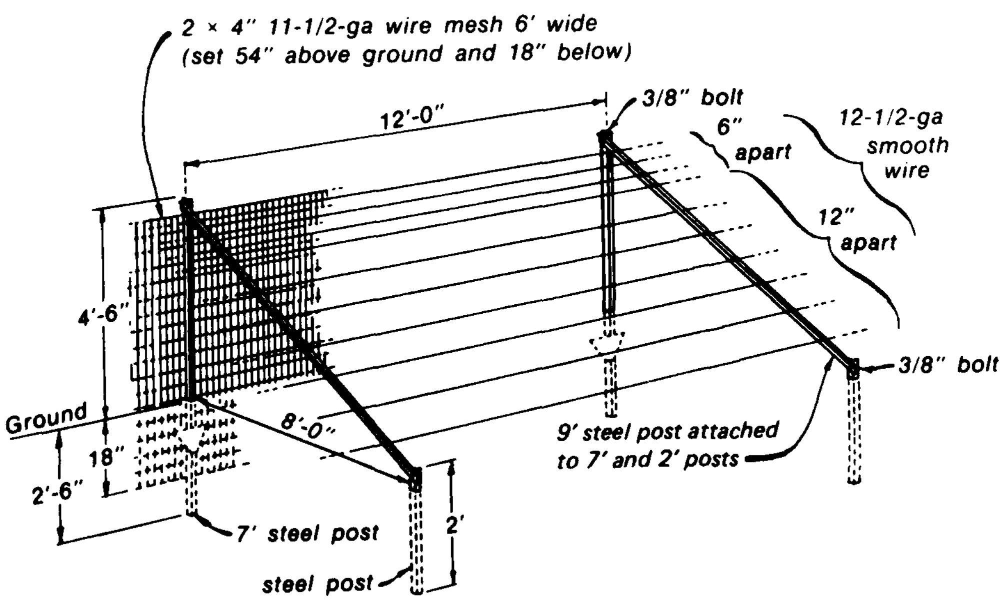


Figure 5. Section of an all-metal slanting deer-proof fence, showing the upright wire mesh and attachment of smooth wire strands (from Blaisdell and Hubbard 1956). Note that the fence is positioned with the high side toward the area to be protected

by wire clips to the fence posts. The slanting portion of the fence is constructed of 9-ft-long steel T-posts bolted to the tops of the upright posts and 2-ft-long metal posts set 8 ft from the upright fence and 18 in. in the ground. Blaisdell and Hubbard (1956) suggested stringing the slanting portion of the fence with strands of 12-1/2-ga smooth wire 6 to 12 in. apart.

PLACEMENT

A thorough evaluation of wildlife resources may be needed to determine if and where wildlife-proof fencing should be installed (U.S. Fish and Wildlife Service 1978). Fence placement for an enclosure requires long-term monitoring of resources and intensive management. The following factors should be considered before enclosing an area with a deer-proof fence: (1) carrying capacity of the land, (2) variety of habitat types and their ability to meet requirements of wildlife, and (3) soil types, as they affect vegetation growth and nutrition.

Wildlife-proof fences are often necessary around concrete-lined canals, outlet works, highway rights-of-way, revegetation zones, fragile riparian areas, and nesting sites subject to severe predation. Latham and Verzuh (1971) and Seaman (1977) (as reported in U.S. Fish and Wildlife Service 1978) reported that deer drownings account for 95% of the big-game losses around concrete-lined canals. Concrete-lined canals without wildlife-proof fencing and surrounded by suitable habitat can have annual losses of 1 or more deer per mile. Fences may be used to confine experimental animals or exclude others from plots where grazing is not desired (i.e., orchards, irrigated pastures, crops, newly established food plots, and experimental plots).

Deer crossing highways present a major obstacle for motorists. Approximately 22,000 (Puglisi et al. 1974) and 12,000 (Reed et al. 1975) deer-vehicle collisions occur annually in Pennsylvania and Wisconsin, respectively. Puglisi et al. (1974) found fence location to be important in preventing wildlife injuries or deaths on highways. Highest deer kill per mile occurred where good cover was within 25 yd of the highways, regardless of vegetation type. Grazing areas are typically available along both sides of a fence and within range of cover. Therefore, fences should be located more than 25 yd from cover and where grazing sites are available to deer without crossing the fence. If impassable fencing is installed along highways, one-way gates are recommended to provide an escape route for deer that have become trapped on the highway right-of-way (Reed et al. 1974). Where highways cross wildlife migration routes, impassable fencing can be located to direct wildlife to safe crossings or underpasses (Reed et al. 1975).

Impassable fences can also be used to protect nesting sites of upland game birds and waterfowl. They have been used around playa lakes and potholes where waterfowl nest. In North Dakota, Lokemoen et al. (1982) found that waterfowl production was greater on sites protected by predator-proof fences.

PERSONNEL AND COSTS

There is a wide variation in cost and durability of fences relative to geographic area, purchase quantities, number of watergaps, and type of labor used (Jones and Longhurst 1958, Thompson 1979). The cost of installing and maintaining impassable upright fences can be substantial, and continued maintenance is often necessary (U.S. Fish and Wildlife Service 1978); however, the expense can be justified economically in view of its effectiveness against wildlife damage and success in preventing wildlife injuries and death in unsafe areas (Longhurst et al. 1962). The average price for upright deer-proof fencing is $1.50/ft (1984 prices); labor costs are approximately $1.00/ft.

Construction costs for a slanting fence are generally lower than for an upright fence (Messner et al. 1973). Slanting fences require shorter posts and about one-half the wire mesh used in an upright fence. Additional savings on slanting fence costs are possible by attaching the slanting fence to an existing upright conventional fence (Blaisdell and Hubbard 1956). Construction of a 6-ft-tall predator-proof fence takes approximately 220 man-hours/mile (DeCalesta and Cropsey 1978).

MAINTENANCE

Maintenance costs are greater for impassable fences than for conventional fences and are dependent on terrain, soils, number and size of watergaps, trails, and vandalism. The major maintenance problem is brush control around the fence line. Additional maintenance problems applicable to impassable wire fences are presented in Section 5.2.1, Conventional Wire Fences.

CAUTIONS AND LIMITATIONS

Fence damage by livestock and deer is a common problem on range sites (Wade 1982). White-tailed deer (*Odocoileus virginianus*) are noted in many areas as a major cause of fence damage due to their habit of stretching and breaking openings in wire mesh in order to pass through, in turn providing ready access for other species. Deer can readily pass under gaps in fencing 9 in. high (Falk et al. 1978). Javelina (*Tayassu tajacu*) and wild hogs (*Sus scofa*) are also known to damage fences by digging under and pushing the wire up. Armadillos (*Dasypus novemcinctus*) are noted for burrowing under net wire fences, thus encouraging access by dogs and coyotes (*Canis latrans*) (Wade 1982).

Weather-related fence damage is also common. Heavy rains tend to cause soil erosion and washouts under fences, particularly at trails, gullies, and creeks (Wade 1982). Fences should be designed to withstand periods of high water by using the correct type of watergap and breakaway sections, and the proper materials should be on hand to quickly replace damaged sections. Damage also occurs from falling timber, windblown sand, heavy snowpack, and high vegetation; therefore, fences should be cleared of debris and the damage promptly repaired. Fences should be inspected for damage caused by snowpack in the spring following snowmelt.

Wildlife enclosures present special problems in controlling wildlife populations. The logistics of removing excess animals can be very difficult. However, population control must be carried out continuously to protect the resources. Deer-proof fences may hinder the movements of certain wildlife species, but most species will adjust to their presence. Additional cautions applicable to impassable fences are presented in Section 5.2.1, Conventional Wire Fences.

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