WILDLIFE COMPATIBLE FENCING

Arizona Game
and Fish Department

ARIZONA GAME AND FISH DEPARTMENT MISSION

To conserve, enhance, and restore Arizona's diverse wildlife resources and habitats through aggressive protection and management programs, and to provide wildlife resources and safe watercraft and off-highway vehicle recreation for the enjoyment, appreciation, and use by present and future generations.

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Guidelines for Wildlife Compatible Fencing

INTRODUCTION

Fences are as much a part of the west's landscape and culture, as are mountains and prairies. The divergence between the mobility needs of wildlife and the need for control of domestic animals has led to challenges regarding how to accommodate one without compromising the other.

Damage caused by wildlife attempts to cross fences increases maintenance costs and creates openings for livestock to escape. Entanglement and impalement are two deadly effects of inappropriate fence design or placement. Habitat fragmentation, however, can have a greater impact on wildlife populations, especially to such species as pronghorn (Van Riper and Ockenfels 1998).

Improperly designed or located fences can dramatically reduce the carrying capacity of a given area. Impermeable fences can fragment habitat into small islands of resources, and prevent access to resources or increase the energy required for wildlife to take advantage of resources.

The Arizona Game and Fish Department (Department) developed these guidelines to assist the landowner, project manager, land management agency, and others in designing wildlife compatible fences. The focus is on fence design rather than detailed fence construction specifications. The goal is to provide guidance in designing a fence that will achieve its objective with minimum impact to wildlife.

Figure 1: A deadly fence design for ungulates
Woven wire mesh topped by 2 closely spaced strands of barbed wire
Randy Gaza

IMPACTS OF FENCING ON WILDLIFE

Fencing is generally intended to restrict movement of livestock, but incidentally may impede wildlife access to critical resources (e.g., water, forage, fawning grounds, cover) or restrict escape or migratory routes essential to the well being of individuals and populations. Impacts can vary based on the animal's age, season, and resource availability. The impact of a fence design on a species is largely determined by the animal's agility and behavior.

Ungulates

Adult deer and elk are prodigious jumpers. A substantial barrier (a combination of vertical and horizontal 8 feet) is usually required to prevent adult elk and deer from crossing. Juvenile elk and deer however, may not be able to cross fences that adults cross. Deer fawns and elk calves will go under fences if there is adequate space.

A recent study in Utah (Harrington and Conover 2006) estimated one ungulate per year becomes tangled for every 2.5 miles of fence. This estimate does not include animals that may have been injured or scavenged by predators and thus not counted. They also found that the use of woven wire fencing more than doubled the mortalities. The increase in mortalities was due to fawns found curled up next to the impenetrable woven wire fence.

Pronghorn, although capable of jumping, prefer to go under a fence and will walk the fence line looking for a space high enough to cross under. Pronghorn are the species most impacted by habitat fragmentation due to unsuitably designed or placed fences. Restrictions to seasonal movements and access to fawning grounds can dramatically reduce pronghorn populations.

Figure 2: Bighorn can go through, under, or over most fencing
Christine Page

Bighorn sheep are also capable of jumping, but generally will go under or through a fence if clearance is adequate. Immature (3-5 year old) rams are particularly vulnerable to barbed wire

fencing when the wires are too close together (Helvie 1971). Immature rams sometimes poke their heads between two wires, and when they pull back get their horns tangled in the top wire. While struggling to escape, the barbs can also cause abrasions and fatal injuries.

Javelina can penetrate most range and right of way fences, but well-built small mesh woven wire or chain link will be an effective barrier. Determined javelina can push through or under old or poorly constructed fences,

Other big game animals

Bears and mountain lions are generally not seriously hampered by conventional barbed wire fencing. Woven wire fences may be an obstacle to bears, but they are generally able to find ways to circumvent the fence. Fences to exclude or contain bears and mountain lions are usually site specific designs and are not covered in these guidelines.

Turkeys too are generally not impacted by fences. Even juveniles can go over or under conventional livestock fences by the time they are old enough to leave the nesting area.

Birds

Most bird injuries or mortalities from fencing are due to lack of visibility. Raptors in pursuit of prey, and waterfowl or wading birds attempting to land on a water body, are particularly vulnerable to the nearly invisible wire strands. Wire fences located across water bodies in areas with high bird traffic, or fences with previous bird mortality, should be modified to become more visible. Visibility can be increased by enclosing the wire in a light weight length of black high density polyethylene (HDPE) pipe. A slot can be cut down the length of the pipe or conduit, and then sleeved over the wire. Fencing can also be made more visible to birds by attaching reflective or colorful weather-resistant flagging materials (e.g., aluminum or plastic strips) to the wire.

Figure 3: Wire fences strung across water bodies can be deadly to waterfowl
Mark Gocke

Figure 4: Birds of prey may not see wires when in pursuit
Doug Wood

Single strands of electrically charged fences ("hot wires") have the potential to electrocute small birds. When a small bird sitting on an electrified wire, touches a ground (e.g., metal t-post, fencing), the electrical circuit is completed. This may result in electrocution.

Amphibians and Reptiles

Most amphibians and reptiles are not hampered by conventional livestock fencing. However, desert tortoises and Gila monsters are exceptions if chain link or other relatively fine mesh fencing is extended securely to the ground. Unless the intent is to prevent these animals from moving into an area, wire mesh fencing should be placed about 6 inches above the ground to allow desert tortoises and Gila monsters to pass underneath.

Bats

Fencing that crosses water sources may dramatically reduce usability for bats. Bats typically drink on-the-fly and the presence of an obstacle may eliminate accessibility, present a hazard, or increase the energy expenditure for obtaining water. Most bats require a water source at least 10 feet long by no less than 2.5 feet wide. Whenever possible, fencing should be modified to minimize restrictions for on-the-fly access to the water (Tuttle et al. 2006). More bat specific information can be obtained from Bat Conservation International (http://www.batcon.org/index.php/what-we-do/water-for-wildlife.html)

IS THERE A NEED FOR A FENCE

Figure 5: Large concrete blocks used to prevent vehicle entry
Christine Paige

Fencing can be a barrier to wildlife, therefore, consider first if a fence is the best method of achieving your goal. Relocating water and food sources or other attractants may accomplish the same goals without the need for fencing. Natural barriers or designs using natural materials (e.g., boulders, hedges) may be more effective than a fence at preventing access or providing privacy, plus they provide a more "natural" appearance while minimizing maintenance requirements.

Figure 6: Rock "fence" used by ADOT to direct elk movements
Marcel Huijser

STEPS IN FENCE DESIGN

STEP 1: Define the purpose of the fence, determine the species potentially impacted by the fence, and identify the daily or seasonal wildlife movements in the area.

Possible primary purposes of a fence may be to enclose livestock, exclude wildlife, or direct the movement of livestock and/or wildlife to a particular area. It is essential to consider not only the target wildlife species, but also those that might be unintentionally impacted. Unless it is necessary to exclude target wildlife species, choose fence designs and placement permeable to wildlife known to be in your area.

STEP 2: Consider the location of the fence.

Factors such as type of soil, topography, water, accessibility, boundaries, legal, budget, and regulatory requirements, visual impact, vegetation, and safety must all be considered in selecting a fence design. Be sure to evaluate seasonal (i.e. snow accumulation or flooding) or other periodic events that may impact the functionality of the fence.

Many state and federal agencies have their own standards for fencing on public lands and should be consulted before any actions are taken. In addition, in the rural/urban interface, communities or developments may have regulations that will affect the choices available.

STEP 3: Evaluate cost effectiveness and potential impacts of alternative fence types. Be sure to consider durability, construction and maintenance costs, and in some cases aesthetics.

STEP 4: Select a fence type and design the fence. Identify materials, location, dimensions, spacing, and construction specifications.

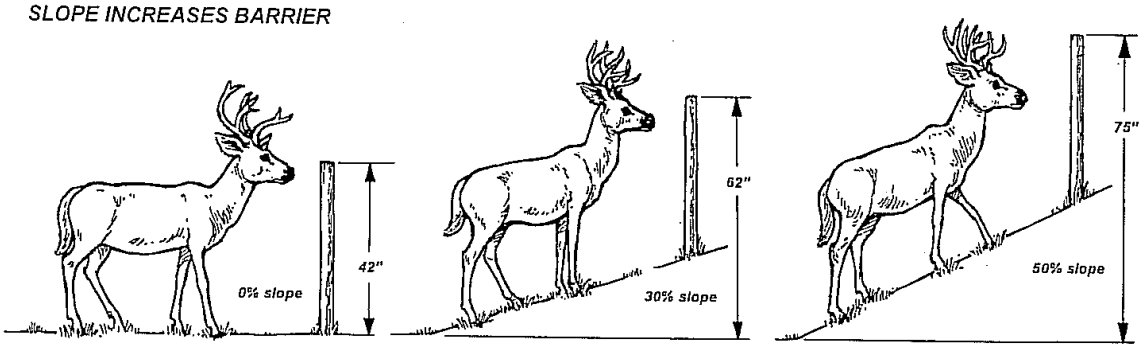

Figure 7: Topography can increase fence effectiveness
Montana FWP

TYPES OF FENCING MATERIALS

Barbed wire: In large scale livestock applications, barbed wire will generally be the most cost-effective fencing material. Barbed wire consists of 2 twisted strands of 12 ½ gauge galvanized steel wire with a 2-point or more barb pattern spaced 5 inches apart. Generally these wires are attached to metal T-posts set in the ground 10-20 feet apart with one or more stays between posts.

Barbed wire fences are effective at restraining livestock and if properly designed can be permeable to most wildlife.

Smooth wire: Smooth wire is the same basic design as barbed wire but without the barbs. It is generally used in conjunction with other materials or in situations where barbs are not needed.

High tensile wire: High-tensile wire is a single strand of smooth wire. Generally it is used either in combination with other fencing materials, or as the primary barrier in an electric fence. It is usually low maintenance, but unless electrified does not provide sufficient deterrent to function as a stand-alone livestock fence.

Woven wire: referred to as "game fence", "sheep fence", "hog wire", or "field fence" this material is composed of multiple strands of horizontal and vertical wire "woven" into a mesh pattern of squares (see Figures 1 & 19).

The woven wire fencing is produced in heights from 2 feet to 8 feet and with a variety of mesh sizes. The size of the openings in the mesh pattern may vary from top to bottom. Typically the wire is attached to metal t-posts spread 15-20 feet apart. This wire was commonly used in ranching applications where cattle were gathered in smaller spaces and held for short periods of time. Woven wire fencing is also commonly used to enclose sheep pastures.

Post and pole (or post and rail): fences made from these materials typically use rounded wood rails, attached to wooden posts set vertically in the ground. These fences are picturesque and are often used in settings where aesthetics are important.

Buck and Pole (or jack leg): This fence also uses rounded wooden rails, but instead of vertical posts uses a triangle of wooden poles (bucks) to provide the vertical structure of the fence. The rails are then attached to the triangle.

Pipe rail fencing: Pipe rail fence is typically composed of small diameter (e.g., ½ inch-1 ½ inch) steel pipe or solid rod rails (e.g. sucker rod) and larger diameter (e.g., 1 ½ inch-2 inch) posts. It is attractive, effective, and low maintenance, but can be expensive to build. Pipe rail fences are often used to protect small areas of sensitive habitat (e.g., springs or wildlife water developments) from livestock and feral burros, and in areas where wildlife crossings are expected to be frequent. Pipe rail fences can also be used to exclude off road vehicles.

Figure 8: Buck and pole fence
Dillon Fencing

Electric fencing:

There are two main types of electric fences: high tensile wire and braided plastic with a metal strand imbedded (electric rope). Electric fencing can be used as a stand-alone fence or in conjunction with other fence types. In most applications the fences can be powered by energizers using batteries recharged from solar panels.

High-tensile electric wire fences consist of multiple single strands of stainless wires attached to fiberglass posts, or plastic standoffs (insulators) attached to wooden, metal, or plastic posts.

Material costs for a 3-wire high tensile electric fence are roughly 60% of a 4-wire barbed wire fence and maintenance costs are roughly equal (Wyoming 2002), but designing the fence and selecting the appropriate components can be complex. The Department recommends consulting with an experienced fencing contractor to design the best electric fence for a given application.

The primary cause of failure of an electric fence is improper grounding due to design or failure to control vegetation growing into the electrified wire(s).

Braided electric rope consists of a double helix of metal conductors and plastic filaments braided around a central polypropylene core. The rope can be secured to posts using plastic, glass, or ceramic insulators. Braided electric rope fences are easily installed and make excellent temporary or moveable fences.

WILDLIFE PERMEABLE FENCING

STANDARD RIGHT OF WAY FENCING

Right of Way (ROW) fencing is intended to keep livestock off roadways. In most cases, ROW fencing should be designed to be permeable to wildlife. The typical ROW fence is composed of 4 strands of wire. To be permeable for deer and elk, the Department recommends the top and bottom wires should be barbless, and the middle two barbed.

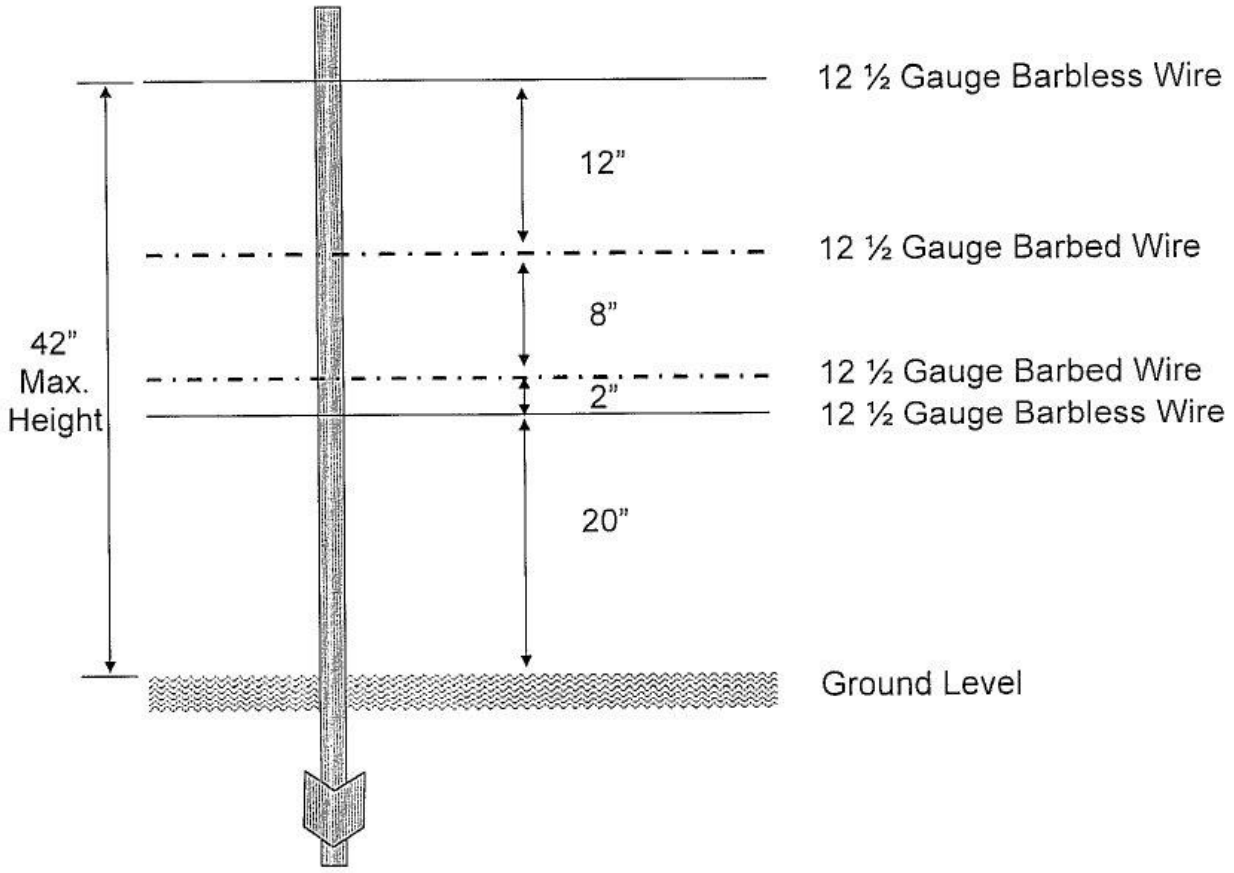

Figure 9: Standard ROW fence in pronghorn habitat

The Department's recommended maximum height is 42 inches and the bottom should be smooth wire 18 to 20 inches off the ground to allow pronghorn and deer fawns to go under. (Note: Arizona Department of Transportation standard fencing (Std. C-12.10) has a 16" bottom wire and the top wire is barbed. Any fencing on ADOT right-of-way should conform to ADOT standards). Anything less than 16 inches off the ground becomes a significant barrier to the passage of pronghorn. The top wire should be at least 12 inches above the second wire to minimize chances of deer or elk becoming entangled when they jump the fence.

Distance from Roadway (Setback)

For many species the roadway and the attendant vehicle traffic can be a significant barrier. Adding a fence on both sides can make it impassable to some species like pronghorn.

Large bodied species (i.e. ungulates) can become trapped within the right of way fencing. Approaching traffic can panic the animal and cause them to enter the roadway where they become a hazard.

The Department recommends that right of way fencing be located as far from the roadway as practicable. In pronghorn habitat we recommend a 300' buffer between the edge of the roadway and the ROW fencing.

Figure 10: Deer crossing under 18" fence
Great Gray Imagery, Troy MT.

UNGULATE CROSSINGS

To further enhance permeability in areas with high activity, elk and deer crossings should be built into right of way fences approximately every ¼ mile. Crossings are easily constructed from a length of high density polyethylene (HDPE) or gray UV protected plastic electrical pipe, with a slot cut down the length of the pipe.

To install an ungulate crossing plastic pipe structure, first remove any stays in the fence section and then slip the top two wires through the pipe slot, bringing the wires together. This should bring the height down to about 36", increase visibility, provide a low hazard top wire, and allow most adult and young animals to cross safely.

The same procedure used on the bottom two wires can provide easy passage under the fence for young animals and pronghorn.

Figure 11: Installation of crossing structure: Note the plastic pipe slipped around the top and bottom wires
Montana FWP

For sections of fence frequently crossed by ungulates, requiring frequent repairs, consider installing a rigid elk/deer jump constructed from rebar, steel pipe, or tubing. The jump is essentially a section of fence, with a lower indentation in the center. Wildlife jumps are designed to replace small sections (less than 20 feet) of fence between posts. They are readily visible to wildlife, safer to cross than wire fences, and designed to withstand the largest ungulate's weight.

Figure 12: Simple elk or deer jump
AGFD Fencing Guidelines June 2006

SPECIES SPECIFIC RECOMMENDATIONS

Pronghorn: The primary consideration for pronghorn is the height of the bottom wire. Anything less than 16" becomes a barrier to pronghorn movement. Substantial snow cover can reduce pronghorn's ability to go under or over fences. In areas subject to severe snow accumulation or in major migration routes, it may be necessary to install additional gates or let-down sections of fencing. Clearing brush and tumbleweeds that build up on fences may also be required to maintain permeability.

Bighorn Sheep: Bighorn will go over, under or through most fences if the spacing between wires is adequate. To be permeable to native sheep the Department recommends a three wire fence no more that 39 inches high, top and bottom wires barbless, and the middle wire barbed. T-posts should be spaced 20-25 feet apart and at least 3 stays should be equally spaced between posts. The bottom wire should be 20 inches off the ground, the second wire 15 inches above the bottom, and the top wire 4 inches above the middle wire.

The 4 inch top spacing represents an entanglement threat to deer and elk (see Figure 1). The Department recommends 12 inch spacing for fences in deer or elk habitat. In areas where bighorn and deer or elk share the habitat, the Department requests the fence designer contact the appropriate Department wildlife manager for specific recommendations.

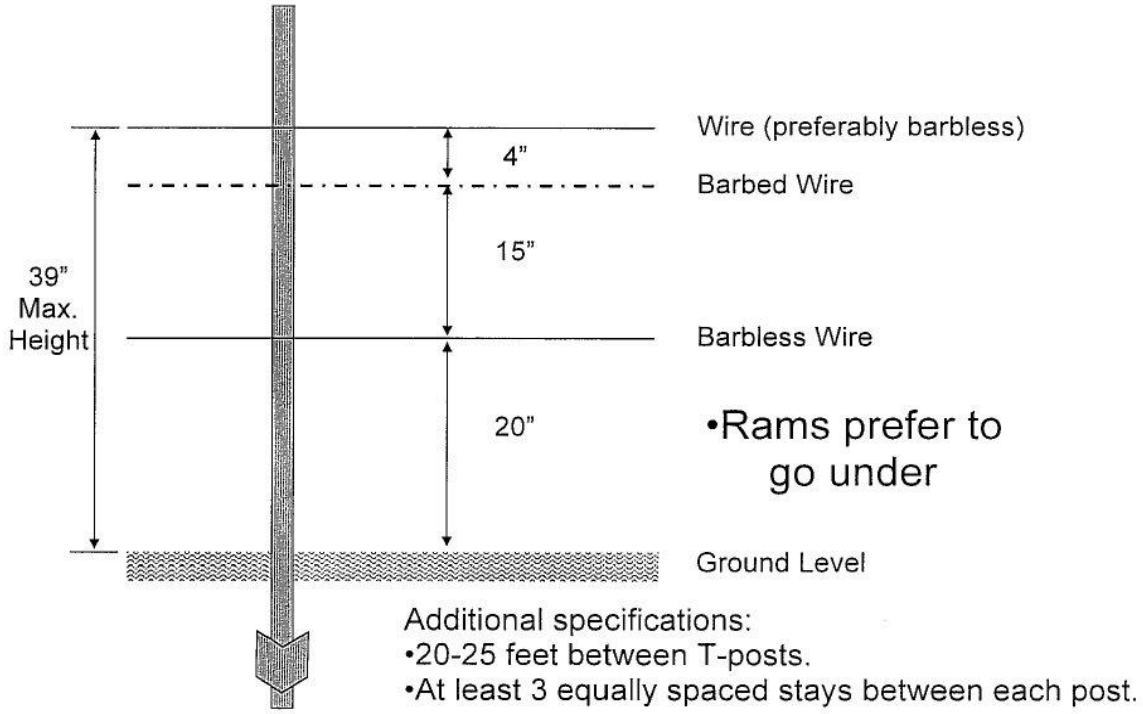

Figure 13: Big horn sheep permeable fence
AGFD Fencing Guidelines June 2006

Deer, pronghorn, and sheep, but not elk or livestock

To allow deer, pronghorn, bighorn sheep and small animals to cross a fence not permeable to elk or livestock, a special "crossing structure" has been designed and tested (Ver Cauteren et al. 2007). The structure is a "ladder" built into the fence. The ladder is composed of two 10 foot vertical wooden posts 20 inches apart. Cross members are installed every 20 inches. Deer, pronghorn, and sheep can go below the lowest cross member or between the second and third. People can use the structure as a ladder. Adult elk and cattle cannot pass through.

Figure 14: Ladder/stile crossing structure
Kurt C.VerCautern, USDA

BOUNDARY/PASTURE FENCING

In Arizona, most fences are intended to confine livestock to a pasture or allotment, or to mark boundaries between adjoining land parcels. Boundary fences are commonly 3 strands of barbed wire.

Whenever possible, the Department recommends the top wire of pasture or boundary fence be 12 ½ gauge smooth wire and no more than 42 inches above the ground. The second wire should be 12 ½ gauge barbed wire and at least 12 inches below the top wire to reduce chances of deer becoming entangled in the fence. In pronghorn habitat the bottom wire should be 12 ½ gauge smooth wire, at least 18 to 20 inches above the ground. In weaning pastures and other areas with special requirements 18 inches may not be adequate to restrain calves. Typically, however, calves will return to the cow as long as the fence is consistently 18 inches. Anything below 16 inches is virtually impermeable to pronghorn and should not be used where permeability is desired.

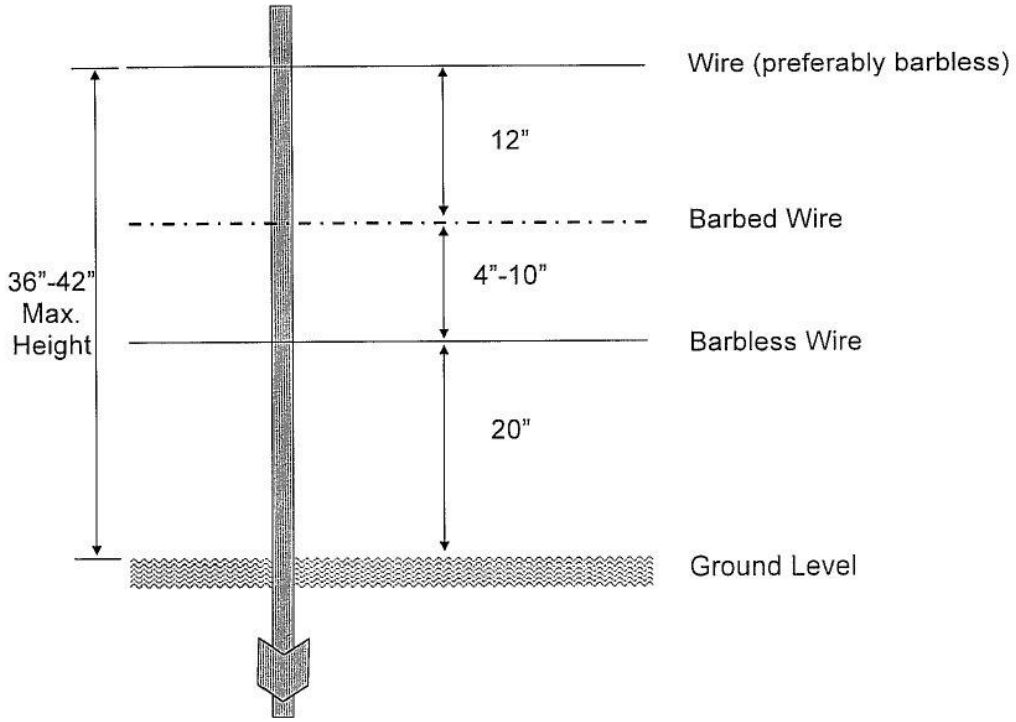

Figure 15: Recommended three-strand pronghorn permeable fence
AGFD Fencing Guidelines June 2006

Where deer and pronghorn share the range with domestic sheep, a 4-wire sheep fence is recommended with a top wire no higher than 32 inches and a smooth bottom wire at least 10 inches off the ground.

Where sheep and cattle share the range the top wire can be raised to 38 inches, as long as there is at least 10 inches between the top two wires and the bottom smooth wire height of 10" is maintained (Wyoming 2002)

To accommodate pronghorn movements the Department recommends sheep fences in pronghorn habitat be constructed with lay-down sections that can be dropped when sheep are not present or during severe snowstorms.

Post and pole fences can be made wildlife permeable by not exceeding 48 inches in height and maintaining at least 16 inch between rails. This spacing allows most adult ungulates to go over the fence and younger animals to go through or under.

Electric fences can be designed to be permeable to most wildlife and are very effective as containment fences for livestock and even bison (with a sufficient electric charge). When electric fences are intended to be permeable to wildlife, the Department recommends the bottom wire not be electrified.

FUNNEL/NON PERMEABLE FENCING

Fencing is often used to direct (funnel) wildlife to a specific area, such as road and highway crossings. Funnel fencing is used to prevent wildlife crossing at high risk points and guide them to safer crossings (e.g., underpasses, overpasses, bridges, culverts) or to open areas with adequate visibility to allow motorists to avoid collisions.

Exclusion fencing may be required to prevent wildlife (or feral animals) from competing with livestock, or damaging sensitive areas such as aspen stands, riparian areas, and springs. These fences need to be impermeable to target species, but not present an entanglement or impalement risk to any species.

Wildlife Escape Mechanisms

When exclusion or funnel fencing occurs along roadways, escape mechanisms need to be built in to allow animals that penetrate the fencing to exit the ROW. Typically these escape mechanisms are engineered ramps with funnel fencing leading to a constructed slope with a sudden drop such that animals can jump down (but not up).

Figure 16: Escape ramp allows animals to exit but not enter

Slope jumps are similar to an engineered ramp but capitalize on natural features to create a difference in grade. Unidirectional gates can also be designed into the fence to allow safe passage. In some situations the use of motion sensors to open animal-activated gates may be preferred. For more details on escape mechanisms visit the ADOT website on wildlife connectivity (http://www.azdot.gov/highways/EPG/EPG_common/wildlife_connectivity.asp .

Deer

Deer can be excluded, funneled, or directed in a specific direction by use of an 8 foot tall fence. The fence can be completely built from woven wire or a combination of a bottom section of woven wire and top strands of smooth wire.

A combination fence is constructed with a bottom course of 47-inch high woven wire, a top course of 26-inch high woven wire and two strands of smooth wire above the woven wire. The bottom course should be a 6 to 8-inch mesh. Less than 6-inch may be a barrier to non target species.

Figure 17: Eight foot woven wire fence
Christine Paige

Pronghorn

Although capable of jumping, pronghorn prefer to go under fences. A 5-foot tall woven wire/mesh fence is sufficient to exclude or funnel pronghorn under most circumstances.

If the purpose of the fence is to restrict highly agitated or stressed animals (e.g., during roundup or capture) the 8-foot tall woven wire fence described for deer may be preferable.

Javelina

Javelina are not jumpers, but they can be very determined foragers and in some cases will push through poorly designed or built fences. Absolute exclusion of javelina requires a solid 4 foot wall or a substantially built fence with regular maintenance.

Electric fences are also effective, inexpensive, and safe for use with javelina. Be aware some local authorities have ordinances limiting the use of electric fences. A single strand of wire 8 to 10 inches above the ground can be very effective for excluding javelina.

Many feed, hardware, or home improvement stores carry the materials, equipment, and information necessary to install an electric fence.

Elk

Elk can be very persistent in attempts to access scarce resources. There are many reports of elk breaking down fences over time, or enduring shocks to penetrate electric fences. In areas with high elk activity, maintenance will be critical. At least five types of elk exclusion or funnel fencing can be effective:

1. Buck and Pole

The buck posts of an elk exclusion fence should be at least 8-feet long and angled such that the base of the triangle base is at least 2-feet (Figure 9). Even though the poles will be less than 8' high due to the angle, elk are not willing to jump this style fence because they cannot clear the horizontal distance created by the angle of the posts.

2. Extended right-of-way with barbed wire extension

A standard ROW wildlife fence height can be extended by placing extension sleeves on top of the existing t-post, then placing an additional t-post into the sleeve. With the extension, the t-post stretches to 8-feet tall and 2-4 strands of barbed wire can be run on the top post to raise the total barrier height to 8-feet.

3. Extended right-of-way with braided electric rope.

A standard ROW fence can be raised to $7^{1/2}$- feet or higher using fiberglass poles affixed to existing standard t-posts. Two or more strands of braided electric rope can be attached to the fiberglass poles and then electrified.

4. Eight-foot tall woven wire fence.

The same fence as described for deer can be effective for elk (Figure 19).

5. Seven foot tall, 8-strand braided electric rope fence.

Using 9-foot fiberglass poles as posts, electric rope can effectively exclude elk. Like other electric fences, vegetation must be periodically removed to prevent grounding and maintenance is critical.

Bighorn Sheep

Bighorn can jump over most conventional fences. Any containment, funneling, or exclusion fencing needs to be at least 8-feet high. The woven wire exclusion fencing used for deer, or the extended ROW with barbed wire used for elk, will also work for bighorn.

Figure 18: Bighorn can go over, through, or under most fences
Christine Paige

Buffalo

To a buffalo, a fence is just a suggestion! The Department's current recommendation is a 5 strand barbed wire fence with a 3/8 inch cable on top. The cable should be elevated approximately 5-feet off the ground and the bottom wire should be smooth wire 18-inches off the ground (20-inches in pronghorn habitat).

Electric fences can also be effective, so long as the buffalo has ample resources inside the fenced area (Wyoming 2002).

Coyotes and Wolves

To exclude coyotes or wolves from small fenced or walled areas (e.g. patios, courtyards) a device known as a "coyote roller" has proven effective. This device is essentially a free rolling tube on bearings, attached to the top of a chain link fence or block wall. When the animal attempts to go over the fence, its front feet cannot get traction on the rotating tube and the animal falls back to the ground. This device is primarily useful where the visual impact of the fence or wall design is important.

When excluding coyotes from larger areas, the Department has found a combination of woven wire and electric fencing effective. The basic 6-foot woven wire fence is constructed using t-

posts, but 12 inches of the bottom edge of fence is either buried in a trench or laid flat on the exterior ground as an apron.

Four strands of high-tensile strength electric wire are run on the outside of the woven wire fence, on insulated 4 or 6 inch stand-offs attached to the t-posts. The bottom wire strand should be 2 to 4 inches off the ground, the second strand 6 to 8 inches above the bottom, the third 8 to 10 inches above the second, and the fourth 8 to10 inches above the third. (Note: The fence in Figure 23 includes a secondary outer electric fence to keep deer from getting close enough to jump the fence. The green shade cloth attached to the inner fence serves as an optical barrier to ensure animals are aware of the fence and avoid collisions.)

Figure 19: Hot-wire/ woven wire coyote exclosure with shade cloth for additional optical barrier
Jill Bright AGFD

These electric fences can be very effective but require regular and frequent inspection and maintenance.

Burros

Burros are not as easily deterred by traditional barbed wire fencing as cattle. Pipe rail fencing can be effective to exclude burros from wildlife waters or other sensitive wetland areas, but allow wildlife access. Pipe rail fencing is expensive and usually not cost effective for larger areas.

Reptiles and Amphibians

"Snake proof" fencing is non-existent, but measures can be taken to greatly reduce their access. Solid walls, a minimum of 4 feet tall, are effective in discouraging snakes from entering an outdoor living area. Adding a solid overhang to the outside top edge of the fence will make it even more difficult for snakes to climb over the top. With any "snake fence" pay particular attention to closing up any small spaces around gate openings and drainage ports through the fence.

In addition to building a physical barrier around your outdoor living space, you can also reduce what attracts snakes to your living space, food and habitat. Removing attractants is usually even more effective than building a physical barrier. Within the living space you want to protect, control rodent populations and fill in their burrows. Also, remove the places where snakes and rodents like to inhabit, like brush piles, stacks of firewood, low dense vegetation, and general debris. If you feed wild birds, eliminate seed spillage or clean it up often to avoid attracting rodents. An even better solution would be to move the feeder outside and far from the living space.

In some circumstances it is necessary to create barriers that prevent movement of reptiles and amphibians (e.g., bullfrogs, tortoises, leopard frogs) into an area. These applications are generally site specific and the design criteria are undergoing continual improvement. Consult the Department's Non-game Branch (623-236-7735) for more information and consultation on these fencing recommendations for reptiles and amphibians.

VEHICLE BARRIERS

OFF HIGHWAY VEHICLE BARRIERS

Some fencing is intended to prevent OHV use of culverts or other potential wildlife crossing structures or to prevent damage to water sources. This fencing should be set back from the structure or water source at least 25 feet to provide wildlife an adequate approach area.

BORDER FENCING

United States Border Patrol (USBP) is charged with establishing and maintaining effective control of the Nation's international border between the ports of entry. To control unauthorized vehicle access across the US-Mexico border, the USBP is constructing two types of barriers. Both types can potentially restrict the movement of some species across the international border if designed without consideration to wildlife needs.

Post and rail vehicle barrier

This style of vehicle barrier uses steel pipes (6 inches in diameter and larger) as the posts, which are filled solid with concrete, and set into a concrete foundation. Posts are spaced approximately 4 to 5 feet apart and horizontally interconnected with a railroad rail or other structurally suitable steel. Horizontal steel rails are welded to the posts.

To prevent livestock from crossing the international border, sometimes smaller diameter steel pipe, tubing, barbwire, or similar materials are attached to the post and rail vehicle barrier. Wildlife can continue to successfully cross a barrier modified to enclose livestock, if the highest wire or pipe does not exceed 42 inches and the lowest is 20 inches above the ground. Twisted smooth wire is preferential for the top and bottom wires to prevent accidental injuries to crossing ungulates. Barbed wire can be utilized in between the smooth wires if appropriately spaced.

Figure 20: Post and rail vehicle barrier
Duane Aubuchon, AGFD

Woven wire attached to the fence can impede some wildlife species from crossing and should be avoided if possible. However, if necessary raising the fencing off the ground 20 inches, and not exceeding a maximum fence height of 42 inches will continue to provide safe passage for most species.

Normandy-style vehicle barrier

Named after the beach barriers used during World War II, Normandy-style vehicle barriers are also utilized along the US-Mexico border. Typically these barriers are built in sections (approximately 24 feet long, 4 to 6 feet high) at a staging area, then transported and set in place along the international border with construction equipment. They are anchored into the ground with concrete and the individual sections are welded together.

Again, to prevent livestock from crossing the international border, sometimes smaller diameter steel pipe, tubing, barbwire, or similar materials are attached to the Normandy style vehicle barrier. Wildlife can continue to successfully cross a barrier modified to enclose livestock, if the spacing guidelines previously outlined under the post and rail section are followed. Additionally, avoid or minimize the attachment of wire strands, pipe, or similar materials to the top of the "x" braces, which creates an overhang, and broadens the width of the fence, making it more difficult for ungulates to cross.

Following the installation of either vehicle barrier type, any older, existing, nearby fences should be removed when possible. Redundant fences in close proximity to the new barrier can deprive ungulates of enough running space to clear the fences.

Figure 21: Normandy style vehicle barrier
Duane Aubuchon, AGFD

RESIDENTIAL FENCING

Residential fencing presents several different and additional challenges. Specifically aesthetics and human or pet safety are the primary concerns.

Decorative Fencing: Many decorative fencing designs (e.g., wrought iron with metal pickets) are hazards for animals that may attempt to cross them. Fencing with pointed or narrow extensions on the top should be avoided.

Figure 22: Impaled mule deer
Jon Hanna, AGFD

Wooden Plank or Picket Fences: These fences can be useful for small areas around the home, but are not recommended for perimeter fencing. If a gate is left open, wildlife may find a way in but not out. This can panic the animal and lead to aggressive or unpredictable behavior toward homeowners, and potentially result in property damage.

Chain-link: Chain-link fencing can be effective in excluding wildlife and providing safe areas for pets and children. If the fenced area will contain small pets, you may consider covering the area between fences with a solid material (e.g. sun screen, plywood, corrugated sheeting) or mesh (plastic or metal), to protect them from avian predators (e.g., owls, hawks).

Bird netting for gardens, fruit trees, and ornamental landscaping: Many species of birds find a homeowner's vegetable garden, fruit trees, or ornamental landscaping a literal "all-you-can eat

buffet". Outlined below are some physical barriers that have proven successful for some homeowners.

Fruit trees: Numerous species of birds will feed on ripe and ripening fruit. Small and medium-sized fruit trees can be protected from birds by covering the canopy with lightweight, inexpensive plastic netting. Many feed stores, plant nurseries, hardware stores, and home improvement centers carry "bird" netting sold specifically to protect tasty plants and fruit from birds. The netting is usually composed of black filaments similar in size to fishing line. The mesh size typically ¾ inch squares, and comes in a variety of sizes (length and width). Multiple smaller pieces can be woven or sewn into one bigger piece with lightweight fishing line, glue, nylon thread, or similar materials.

Plastic netting should be placed over the trees before the fruit begins to ripen. Due to its light weight, the netting can be placed directly on the tree canopy (leaves and branches), using a ladder and /or a long lightweight pole (e.g., PVC pipe). Preferably the sheet of plastic netting you use should be large enough to wrap around the entire tree canopy, with enough netting left over to securely fasten to the trunk of the tree. Fastening to the trunk will help exclude the birds from entering underneath and prevent the netting from blowing away. Securing the netting securely to the tree trunk will also help prevent small animals (e.g., lizards, snakes, and pets) from getting tangled up in the excess netting laying on the ground. Once the fruit is entirely harvested from the tree, the netting should be removed and stored out of the elements until the next season.

Instead of draping the netting over the fruit tree, some industrious gardeners will build a framework around the tree from lumber, PVC pipe, or other materials. The framework can be either permanent or temporary, and the netting is attached to the frame using fishing line, string, wire, or other means.

Vegetable gardens: Plastic netting is also effective in protecting gardens and row crops from hungry birds. A similar framework is first needed to elevate the above the plants. Framework size and height depends on the mature plant size. Materials typically used for the framework include PVC pipe, rebar, lumber, branches, and other simple materials. To be effective the netting should be securely fastened to the ground and the framework. If the garden has fencing around the entire perimeter, it may be easiest to net the entire top, provided the fence is tall enough.

If your local hardware or gardening center does not carry the netting you want, you can find a variety of products at the following websites: http://www.planetnatural.com, http://www.nixalite.com; http://www.americannettings.com.

SPECIAL FEATURES

Pedestrian walk-through gate – If foot traffic is expected to be high through a fence line, a walk-through gate is recommended. A walk-through gate allows easy passage of pedestrians but prevents movement of large animals and unauthorized vehicles.

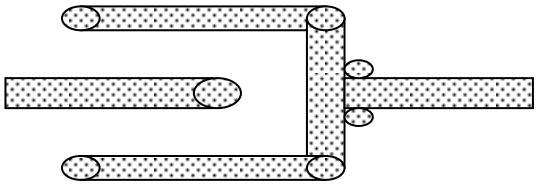

Figure 23: Pedestrian walk-through gate

Top rails – Top rails on any type of fence can provide several benefits. They provide a better visual cue for wildlife judging the height of the fence, reduce unintentional collisions and entanglements, and help prevent damage to the fence.

Vinyl coated top wires- Vinyl coated wire also increase the visibility of the fence and provide many of the same benefits as top rails. In addition, the vinyl coating helps protect the wire from the elements thus lengthening the materials life span.

Let down fencing

Let down fences (Sanderson et al., 1990) are sections of fence that can easily be disconnected from an anchoring structure so that the section can be laid flat on the ground to create openings.

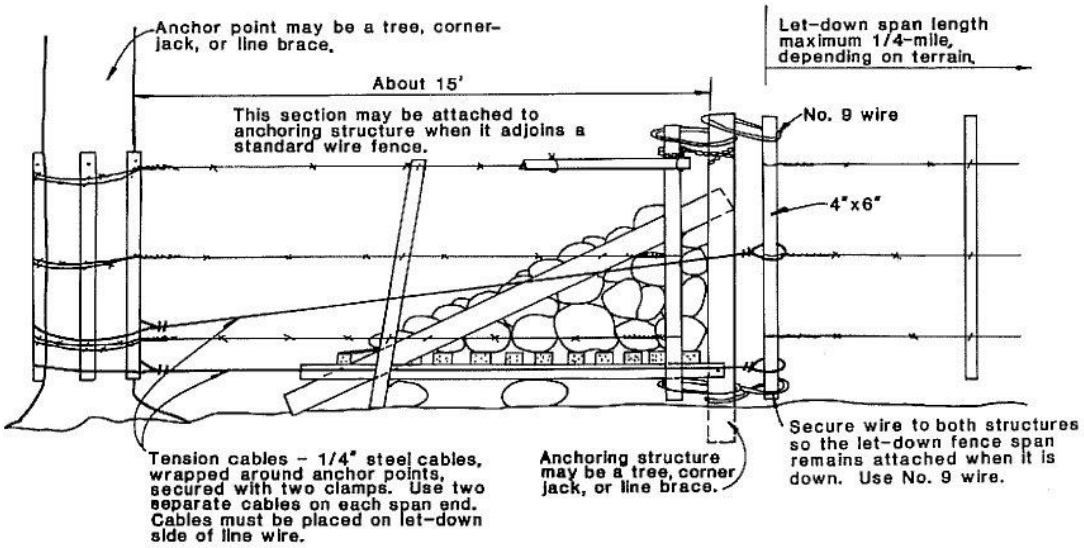

Figure 24 Basic let down fencing

USDA, USFS Specifications for Structural Range Improvements, PNW-GTR-250 Sept 1990

Livestock water troughs and tanks

In many livestock operations the area surrounding the water source is more securely fenced since it is used for gathering and handling livestock. Often these areas are fenced using woven wire, solid fencing, or multiple strands of barbed wire. These types of fencing can be a hazard to wildlife if the water source also serves as an attractant to wildlife.

When possible, the Department recommends water sources be fenced with pipe rail or a heavy duty barbed wire fence permeable to wildlife. Alternatively, water sources should incorporate a wide gate which can be left open when the facility is not holding livestock.

Water Bars

Fencing sections that cross drainages are particularly subject to damage during flood events. Free swinging flood gates (water bars) or breakaway sections of fence are essential at large, active drainages. Water bars are built by suspending horizontal or vertical bars (e.g., large diameter solid rods or rebar) across the drainage, at close spacing's. The bars are sized and spaced to prevent wildlife or livestock from pushing through, but move with sufficient force from flood waters.

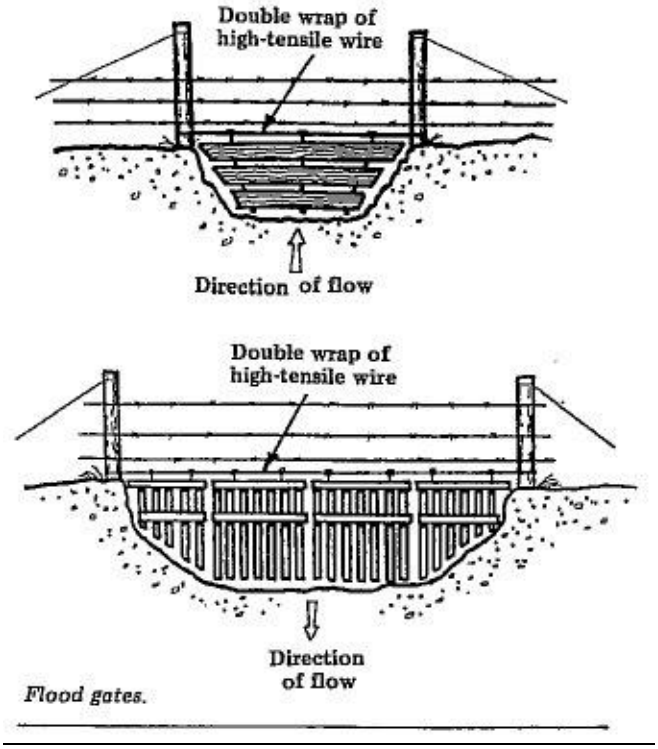

Figure 25: Free swinging flood gates (water bars)
USDI BLM-USDA Forest Service "Fences"

In drainages subject to severe flows, it is recommended a small stretch of woven wire fence be constructed across the width of the channel up-stream from the main fence. This fence will collect debris during floods before it accumulates on the main fence, thus reducing damage to the main fence. The small stretch of sacrificial fence will need to be dug out or replaced after flood events.

MAINTENANCE

All fences require periodic inspection and maintenance. A downed or breached fence is not only ineffective but also presents an entanglement threat to livestock and wildlife.

Wire fences should be kept tight and maintained to reduce chances of entanglement. Periodic brush removal may be required to maintain permeability. If a fence is no longer needed, the Department recommends its removal.

GENERAL REFERENCES

NRCS Specification guide FENCE Code 382. Order book from: Missoula Technology and Development Center, Bldg 1, Fort Missoula, Missoula, MT 59801

Wildlife Friendly Fencing for Teton County, A Resource Notebook for the Jackson Hole Community, Prepared by the Jackson Hole Wildlife Foundation

Fencing Guidelines for Wildlife, Wyoming Game and Fish Department Habitat Extension Bulletin No. 53

Fences, Missoula Technology and Development Center, Building 1, Fort Missoula Missoula, MT 59801, (http://www.fs.fed.us/eng/techdev/mtdc.htm)

Chino Valley Ranger District/Bradshaw Ranger District Prescott National Forest Fence Construction Specifications 06-26-97

A Landowner's Guide to Wildlife Friendly Fences, Landowner/Wildlife Resource Program, Montana Fish and Wildlife and Parks, Helena Mt. 44. pg, 2008.

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Table of Figures