SDSU Extension

BEEF

Chapter 58

Pasture Fences: Innovations

Pete Bauman

Chapter 58:
Pasture Fences: Innovations

Disclaimer: This chapter focuses on innovative application of new or emerging technologies for fencing systems and may include information on certain products or companies that manufacture or distribute products or technologies that are not widely available. SDSU Extension does not endorse any of the products or companies mentioned here. Any inclusion by name is provided solely as a resource for the reader on the unique technology, method, or innovation.

Perhaps the greatest asset of the American farmer and rancher is the propensity for innovation. Just as the pioneers of barbed wire explored fence alternatives, so too are today's progressive livestock managers experimenting with alternative interior fence designs. Here we highlight examples of innovation that have broad application to grazing strategies for SD producers. The objective of this chapter is to highlight variations in fence systems and to challenge the reader to explore non-traditional options for fencing and management that are economically and environmentally efficient, effective, and adjustable. This chapter includes information on:

- Interior Fences
  - Forage and season of use considerations for pasture design
  - Interior fence design
- Fence Innovation
  - Remote 110 volt systems
  - A-frame corner braces
  - Power breaks
  - Livestock powered fences
  - Fenceless systems
  - Center pivot irrigation systems as fences
  - Gate Placement, Access Points, Holding Areas, and Corrals
  - Gate placement and access points for livestock handling and human use
  - Holding areas and pasture corral considerations
  - Portable corrals

Key Points

- Large pastures are common in South Dakota, and the infrastructure necessary to utilize large pasture forages effectively hinges on interior fence design.
- Successful beef producers will recognize the importance of managing where, how, and when cattle graze within larger pastures.
- Basic interior fence design must start with goals, objectives, and an understanding of today's fence options.
- Inadequate or misplaced interior fences can lead to unnecessary input costs, unmet objectives, and a poor management experience.
- Wildlife issues can be mitigated through a variety of fence design options.

- Wildlife Friendly Fencing
  - Birds
  - Large mammals

Interior Fences

Basic interior fence design must begin with goal setting and evaluation. Simply dividing pastures into squares or similar sized paddocks, although sensible on paper, may make little sense when applied on the ground. Vegetation, natural features, livestock handling, intended season of use, and other factors such as prevailing wind direction, shade, and water sources should influence interior fence design. Here we explore various options and considerations for interior fence, beginning with pasture vegetation composition.

Forage composition and season of use considerations for pasture design: South Dakota's pastures and rangelands contain highly variable plant communities. Spatial arrangement of various native and non-native plants and plant communities is dependent upon a variety of factors including climate, precipitation, soils, and historic and recent management (Butler et al. 1997). Historically, most pasture fence systems were established on 'squares' reflecting ownership or legal boundaries, such as sections and quarter sections of land as a result of how property was initially settled by pioneers. This square settlement pattern created pastures that harbored a mixture of various vegetation communities. An example of such would be a single 160 acre pasture that encompassed 80 acres of native warm-season grasses on light upland slopes as well as 80 acres of wet meadow or cattail slough wetlands. Although this type of pasture design allows for both forage and water, without some type of additional barriers (fences), it may be difficult to direct livestock grazing. Over-utilized and under-utilized areas can result, possibly causing long-term and/or undesirable shifts to both upland and lowland plant communities.

Today's fence and water options allow producers to implement improved strategies to utilize variable pasture communities. Over time, plant communities on much of South Dakota's pasture and rangeland have shifted from diverse native plant communities to some combination of native and non-native species. Although similar in arrangement, plant communities can be markedly different in various regions of the state. (For information on specific plant species and plant communities, see the Range Plant Resources reference list at the end of this chapter.)

In eastern South Dakota, this transition is exemplified by the common infiltration of perennial non-native cool-season grass species, such as Kentucky bluegrass *(Poa pratensis)* and smooth bromegrass *(Bromus inermis)*. Many native species considered as grazing 'increasers' are more common as a result of fairly aggressive grazing practices over time in this region. In addition to shifts in plant communities on native pastures, eastern South Dakota has a fair amount of low-diversity go-back pasture areas. These areas are generally old row crop, grain, or hay fields with variable tillage and chemical history. Generally, these fields proved to be unproductive, remote, or otherwise difficult to manage as crop land and thus were allowed to revert back to grazing lands (hence the term go-back). Some were allowed to re-vegetate naturally, while others may have been actively seeded to a grass or forage-based cover (such as a smooth brome and alfalfa mix). The plant communities in these areas can be highly variable and can range from excellent, diverse native communities (uncommon) to low-diversity non-native cool-season grasses (smooth brome, Kentucky bluegrass) intermingled with early successional native and non-native broadleaf plants, such as western ragweed *(Ambrosia psilostachya)*, Canada goldenrod *(Solidago canadensis)*, nonnative thistles *(Carduus spp.* and *Cirsium spp.)*, and sweet clovers *(Melilotus spp.)*.

Western South Dakota's native rangelands are often infiltrated with various species that were either actively planted or have invaded over time, such as perennial crested wheatgrass *(Agropyron cristatum)*, sweet clovers, and non-native cool-season grasses such as cheatgrass or downy brome *(Bromus tectorum)*. Distribution and use of these species ranges from season-long use in large pasture rotations to targeted high intensity/short duration use within specific pasture or paddock based grazing or haying systems. An example would be intense early spring grazing of crested wheatgrass in old

grain fields now utilized as pasture.

In all cases, range managers can take advantage of natural features and various plant communities to design pastures to control season of use and grazing impacts. A simple strategy is the use of semi-permanent or temporary interior fencing to direct or divert cattle toward or away from target areas. As an example, we could use poly wire fencing to split our 160 acre example pasture, concentrating grazing pressure on the uplands during the early spring to take advantage of cool-season introduced grass growth while keeping cattle out of the water source. Conversely, if we assume the uplands are dominated by a healthy native warm-season plant community that we want to graze in mid-summer and the low lying area is infested with an invasive species, such as reed canarygrass *(Phalaris arundinacea)* of limited forage value in mid-summer, we can employ temporary fencing to target the lowland area while keeping livestock off the uplands. Similarly, this strategy can be utilized to target grazing timing and intensity in specific areas of large pastures or fields. Under any scenario, water can be delivered through various semi-permanent or temporary water systems (see Chapters 55 and 56, Pasture Water Basics and Pasture Water Innovations).

Interior fence design: Producers can exercise a great deal of flexibility in relation to interior fences if they've invested in sound perimeter fences (see chapter on fence basics in this book). Interior fences can be constructed of permanent traditional three or four-strand barbed wire, the benefit of such being permanent pasture or paddocks with known acreage and consistent permanent water sources conducive to simple rest/rotation grazing schemes. The downside to permanent interior fencing is excessive cost and limited flexibility.

An option to permanent barbed wire interior fence is to consider semi-permanent or completely moveable (temporary) fence. Semi-permanent fence is commonly constructed of a combination of permanent wood and/or steel t-posts arranged in a fashion that allows fairly simple installation and/or removal of some type of smooth wire (generally either low-tensile or high-tensile smooth electric

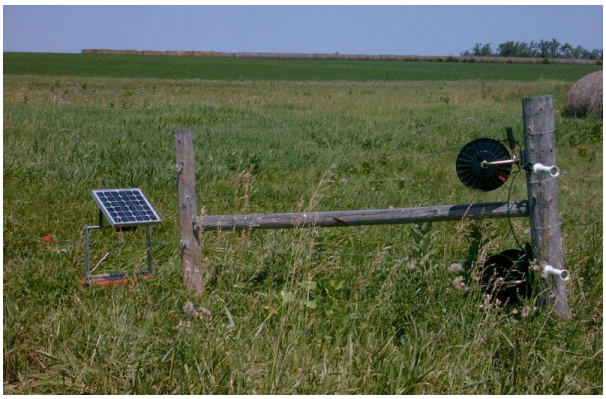

Figure 1: A variety of products exists for creating semipermanent or temporary fencing. Popular options include solar or battery-powered electric energizers (upper left), poly wire spooled on large hand-reels (upper right), and light weight step-in posts for supporting wire or poly wire fence (lower right). Photos by Pete Bauman.

wire). Semi-permanent fences may be left intact for several seasons without major maintenance issues, but will eventually need some basic maintenance. An example of such a fence would be a single or double strand electric fence around a crop field utilized primarily for fall stubble grazing. The benefit of such a fence in a pasture system is that the posts are relatively permanent, allowing for quick installation and removal of the wire. Changes in paddock size and design can be made simply by moving wires to various posts. The downside to semipermanent fencing is that materials (wood and steel t-posts) can be bulky and wires (especially if using high tensile) tend to be difficult to handle when moving or re-spooling.

A second option for interior fencing is temporary movable fence, generally in the form of a single strand of electrified light aluminum braided wire, poly rope, poly ribbon, or the more popular poly wire. Poly wire is a generic term for a lightweight nylon twine braided with light steel, copper, or other conductive wire that is easily spooled and moved. These fences typically utilize press-in or step-in posts comprised of insulated steel, plastic, fiberglass, or combination of materials. Fences are energized via 110V systems if access to electricity is available. More often, such fences are powered by either solar, battery, or solar/battery combination commercial energizers (Figure 1). Several manufacturers provide solar energizers of various performance classes that are typically rated in 'miles' of fence that can be powered.

The variety of manufacturers and products available for temporary fencing can be overwhelming, so a few guidelines should be kept in mind when researching products.

- Product quality and longevity (often projected by the manufacturer)
- Ease of use
- Performance under conditions on YOUR ranch.
  - Heavy or thick vegetation
  - Multiple corners vs straight lines
  - Physical condition of manager or laborers
  - Weight and bulk of the fence materials
  - Time of year of projected fence installations and livestock movements
  - Soils characteristics for grounding
  - Wetlands, creeks, and drainages
  - Livestock temperament and training
  - Wildlife issues
  - Potential sources of increased fence pressure from livestock congregation (Figure 2)
- Gates
- Prevailing wind direction
- Flies and other pests
- Water sources
- Shade
- Inadequate forage
- Neighboring crops

Figure 2: Understanding potential concentration areas on your farm or ranch is important to proper interior and exterior fence design. Prevailing wind direction should be considered when designing permanent or temporary fence (left). Livestock without adequate forage will pressure any fence to reach forage or crops, including pushing on this combination barbed wire/electric perimeter fence to reach low-quality forage in the road ditch (right). Accounting for potential pressures during the fence design phase can minimize long-term fence care and maintenance needs. *Photos by Pete Bauman.*

- Neighboring livestock, especially during the breeding season
- Costs of any specialty tools and equipment necessary for installation and maintenance
- Price
- Local availability
- Technical support, customer service, and practical advice
  - Manufacturer
  - Retailer
  - Neighbors and friends

Fence Innovation

Temporary fences offer ultimate flexibility in grazing control through the ability to modify grazing paddock size and shape when necessary. Paddocks can easily be adjusted to match targeted vegetation communities in large pastures, and stock density over time and space can be adjusted based on observed grazing behavior, vegetation response, or planned rotations. When acquiring access to new pasture, many producers will utilize temporary interior fence while gathering information about the pasture as they plan for future fencing and water investments. Temporary fences are extremely valuable in excluding livestock from sensitive areas, such as wildlife habitat, dams, dugouts, creeks, wetlands, food plots, or experimental areas.

Temporary fencing used for various livestock rotations does require additional labor inputs from the manager. Livestock must be acclimated to the fence, and installation and moving fences will require some training, labor, and limited specialized equipment. Producers who utilize temporary fence for daily or weekly movement of livestock generally invest in design and resources to manage the grazing rotation efficiently. In all cases when electric fence is utilized, it is imperative to manage the vegetation load on the fence, as heavy vegetation loading can detract considerably from the ability of an electric fence to perform consistently. Consistent negative reinforcement is important to ensure that livestock remain continuously accustomed to the fence. Most producers who invest properly in developing movable or temporary interior fence systems believe these systems are far superior to permanent interior fencing for overall ranch management. Once a system is built, it can be quite efficient.

Remote 110 volt systems: A variety of 110V energizers is available on the market. Several manufacturers offer various models of energizers with specific performance ratings (usually rated in miles.), and some models even have options of remote shut-off. This can be a great asset when making electric fence repairs in remote areas of the pasture. Most 110V energizer systems are powered through outlets at the farmstead or other buildings. However, the use of power supply stations connected to existing lower-voltage overhead or buried lines can be an option for remote locations (Figure 3).

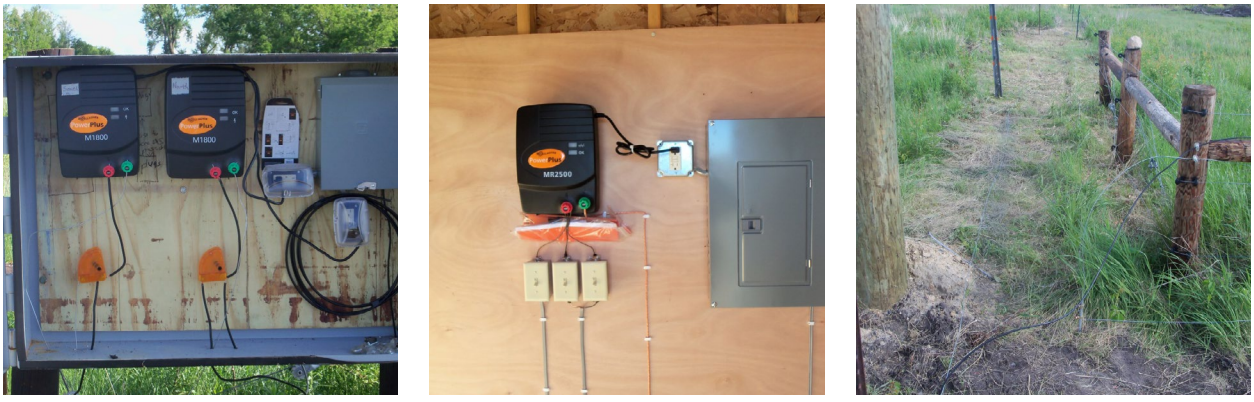

Figure 3: Example of a remote 110V power station (left). Power is supplied by overhead or buried lines to a 110V outlet. Each energizer is protected by a lightning surge protector. Energizer connections can be arranged to either power different sections of fence or to power alternate wires over long distances so that if one energizer fails the fence still has power to at least one wire. Systems can also be designed to power individual pastures or paddocks from a central charger through a series of switches (center). Also shown is a common corner and ground rod station located at the power station (right). Temporary interior fence is powered by connecting poly wire to the perimeter fence via an insulated gate handle to subdivide the interior into paddocks based on grazing plan objectives. *Photos by Pete Bauman and Joe Blastick.*

Figure 4: Wood A-frame braces (left) offer an option to traditional H-Brace corners (center). The long slanted braces eliminate the need for additional posts and are supported by a floating plate (right). *Photos by Pete Bauman.*

The expense of accessing power from an existing overhead or buried line can be highly variable depending on location and local rural electric protocol, but, where available, this can be a great long-term alternative to solar chargers. In addition, remote 110V locations can serve a dual purpose of powering electric well pumps to supply water to livestock.

A-frame corner braces: Although not entirely new, these innovative corner braces are becoming more common in the region. The benefit of this design over a typical H-frame corner brace is the need for one less post. Braces are supported through a system of a floating plate beneath the angled supports, which are tied to the main posts with either high-tensile or barbed wire. In the case of high-tensile wire, installers will utilize a wire ratchet to properly tension the support wire (Figure 4).

Power breaks: Avoiding unnecessary breaks in the power supply is advisable when utilizing electric fences. Typically, breaks in the power supply occur at connecting points, such as gates. Minimizing the number of gates or clustering gates near paddock corners can reduce the time necessary to trouble shoot power issues when they occur. Innovative incorporation of gates that do not require a break in power may reduce fence maintenance in the long term (Figure 5).

Livestock powered fences: Although not necessarily practical for rangeland use, the concept of a frontal or push fence has been tested. Under this concept, the livestock themselves push the fence to gain access to fresh forage. The principal is similar to strip grazing or mob grazing systems where the access to forage is restricted by the fence but where such access is also gained fairly continuously. Although it is unlikely these systems offer advantages to

Figure 5: Gates in electric fences create power breaks and potential maintenance issues, especially in remote pastures. An innovative design to reduce the need for traditional gates incorporates the fence post into the gate. When down, the 'gate' serves as a typical fence post allowing for no breaks in the wire (left). When up, the 'gate' allows for easy passage of livestock or machinery underneath the elevated wires (right). Design and photos by Ken Miller

animal performance, they may be of interest to producers intent on experimenting with different methodologies for controlling livestock access to forage (Volesky et al. 1994).

Fenceless systems: The concept of fenceless grazing operations invokes visions of open range and livestock roaming free. However, such systems may have a place in the future of grazing. Currently, the concept of fenceless grazing relies on common radio/electric technology similar to a dog shock collar. When adapted to livestock, this technology can be utilized to train an individual or a herd to respond to audio and electric stimulus through a transmitter and receiver system. Basically, these systems provide audio and electrical negative reinforcement to encourage the animal to stay within its comfort area (i.e. the desired grazing patch). This technology may provide benefits in reduced fence costs and aesthetics (Quigley et al. 1990). In addition, the use of such systems may have future appeal for public land managers challenged with managing for multiple uses where fences conflict with recreation or other uses.

Center pivot irrigation systems as fences: Grazing forage crops under center pivot irrigation requires the manager to make accommodations to fence design and materials that will allow pivots to move over or between fence lines. Although grazing under center pivot irrigation systems is still relatively uncommon in South Dakota, the potential to utilize pivots for various forage crops may be appealing to some livestock producers. The major hurdle with utilizing pivots in conjunction with paddocks or cells is making modifications that allow the pivot to cross the fence line without causing damage (Nichols 1981, Volesky and Nichols 2006). Figure 6 images are provided by Ken Miller of the Burleigh County Soil and Water Conservation District, North Dakota.

Even less common is the use of pivots as the actual fence to control livestock foraging on irrigated pasture or annual forage crop systems. This is an innovative concept developed by Jason Gross (University of Nebraska Lincoln Extension Service). The system utilizes any brand of center pivot. Prefabricated components suspend the wire off the pivot and incorporates a spring tensioning system to maintain wire tension. A perimeter fence is incorporated on the outside arch of the pivot. Wireless, GPS, and even cell phone or laptop remote control options are available. More

Figure 6: Design of grazing paddocks on pasture located under a center pivot irrigation system. Semi-circle fences are designed to minimize contact with pivot wheel towers while straight fences are designed to allow pivot wheels to roll over fence without damage (top). Pivot wheel towers are fitted with a smooth guide constructed of light steel that allows wire to slide under the wheel tower as the wheels roll over the fence (bottom). *Map and photos by Ken Miller.*

information on this technology is available online through Pivotfence (http://thepivotfence.com/).

Gate Placement, Access Points, Holding Areas, And Corrals

A successful fence system requires an understanding of how livestock, people, equipment, and even wildlife will move through the system. Accounting for the natural tendencies of livestock and laborers will positively influence fence design and ultimately fence longevity. While consideration of livestock movement is critical to operational efficiency and safety, ensuring ease of movement for people can be just as critical.

As livestock managers continue to seek diversification in their operations by incorporating new enterprises such as tourism or hunting, ensuring gates and access points are strategically located is essential. Whether operating independently or incorporating additional enterprises in partnership with neighbors, fence and gate design can often be overlooked. Good access points, ease of movement between pastures, minimizing disturbance to livestock and wildlife, and minimizing damage to clothing and gear can enhance the enjoyment of the manager and the guest and should be considered when designing or updating gate and fence infrastructure. Visiting livestock operations with similar goals and objectives can provide valuable guidance to producers seeking to incorporate strategic fence, gate, and corral designs.

Gate placement and access points for livestock handling and human use: Well planned gate placement can be very beneficial to livestock producers developing or modifying their grazing designs. Keen attention to landscape features and the natural movement of livestock will pay dividends when handling livestock and moving herds through gates. Gates placed in pasture corners or near high traffic areas often provide easier use than do gates located in the center of long fence stretches. In conjunction with livestock needs is human use and access. Gates in permanent exterior or interior fences should be located with future needs of the operation in mind that may include larger herds, larger machinery, or modifications to pastures and paddocks.

Holding areas and pasture corral considerations. Livestock operations that include remote pastures are challenged with developing adequate infrastructure for handling animals during turnout, roundups, or during animal servicing and health procedures. If animals are to be congregated and penned for any purpose, a holding area of permanent materials should be constructed that would allow livestock to be captured and held securely. Within the holding area, producers may choose to construct a permanent corral with a loading facility, scale, and animal handling tools (see chapter on low stress handling in this book). If animals are to be crowded for processing through a chute, a sturdy holding system and sturdy corral area is a must for the safety of the animals and the workers.

When designing or locating a new holding area, paying particular attention to the natural movement of livestock and natural landscape features offered in the area can be important. Water and wind protection are key concerns if animals will be held for an extended period of time. Also, if the holding area is in open pasture, ensuring adequate forage or feed supply is a primary consideration, depending on the time period and number of animals to be held. When incorporating a new holding area into a new or existing pasture, consideration should be given to acclimation of the livestock to the holding area. One way to accomplish this is to incorporate the holding area as a central hub in the overall pasture design, creating movement through the holding areas as livestock are moved between various pastures or paddocks. If the holding area is viewed by livestock as a common place to acquire resources such as water, mineral, or pest control, animals will more readily move to this area during periods when handling is necessary (Figure 7).

Portable corrals: Livestock managers who run cattle herds on large, isolated pastures, rented land, or those that prefer to minimize pasture infrastructure, may opt for use of a portable corral system. Portable corrals are common, and several manufacturers produce corral systems with various options to fit individual needs. Below are various options livestock managers may want to consider when purchasing or renting a portable corral*.

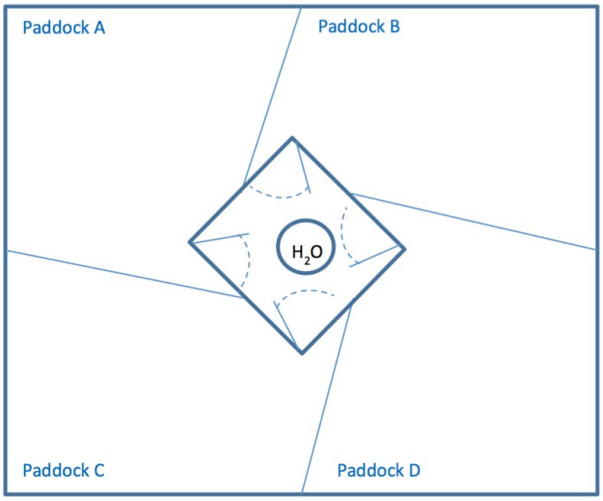

Figure 7: In this simplified example, the holding area containing the water source is centrally located between four temporary or semi-permanent fenced paddocks or pastures. The design allows livestock funnels for moving through paddocks. The holding area and the overall perimeter are constructed of permanent fence materials. The holding area could also contain any number of livestock health or handling facilities, such as mineral feeders, shelter, corrals, loading chute, scale, head gate, portable corral, etc. Each design must be modified to specific livestock and facility needs. Considerations such as electricity, access, and feed needs are also important.

- Ease of use: single or multi-person operation and set-up time
- Capacity
- Trailering and towing:
  - Hitch: bumper or 5th-wheel
  - Wheels:
    - Removable or fixed
    - pneumatic or solid rubber
    - sealed or greased bearings
    - wheel size/clearance
  - Speed rating: highway (most systems are rated for highway speeds)
  - Lighting systems
  - Compactness and overall length
  - Weight: GVWR of tow vehicle and overall corral system weight
- Jack systems: Electric/Hydraulic or manual
- Winch systems: Electric or manual
- Power source: Solar, battery, or other
- Pens and panels:
  - Panel height, size, weight, and ease of use
  - Hinges and latch systems
  - Fixed shape or expandable with additional panels and configurations
- Livestock handling components:
  - Sorting tub
  - Variable alleys and designs
  - Head gate
  - Loading chute
  - Scale: various electronic options available
- Accessories:
  - Battery
  - Power cords
  - Remote controls
  - Racks
  - Storage
- Warranty options
- Price: $10,000 - $20,000 or more depending on capacity and options.

** Information compiled in part by Emily Mack, Field Steward, The Nature Conservancy, Clear Lake, SD.*

Wildlife Friendly Fencing

Wildlife management as part of livestock production is often a low (or forgotten) objective. Although wildlife benefits may initially be overlooked when designing fences, proper design will not only benefit wildlife, but can also have economic benefits in regard to reduced maintenance or expansion of ranch enterprises. Poor fence design can negatively impact resident and migrating wildlife and can unnecessarily put livestock managers at odds with wildlife or conservation interests. Generally speaking, all wildlife from birds to large mammals will benefit from fences tailored to their needs. When properly designed, wildlife friendly fences are also livestock and human friendly.

Birds: Most songbirds and waterfowl navigate pasture fences fairly well with little perceived impact. However, certain species are more sensitive than others to overall structure and may avoid areas with high fence density. The issue of fence density can be minimized with use of temporary interior fences. Also, structural components of permanent fences, such as steel t-posts and wood posts, can provide perch sites for raptors, potentially increasing predation on grassland birds and small mammals.

Finally, barbed wire and woven wire fences have proven fairly detrimental to prairie grouse, such as sharp-tailed grouse, prairie chickens, and sage grouse, as these birds often fly low across the landscape and are susceptible to collisions with fences. Use of more forgiving or highly visible materials, such as electric poly wire or poly rope, in regions where these species are common can be beneficial.

Large mammals: Fences can be a very effective barrier to large animal movements. While mule deer, white-tailed deer, and elk can generally navigate woven and barbed wire fences, these fences can be a hindrance to pronghorns which may generally avoid jumping fences (especially young pronghorn). When used, woven wire fences should be placed far enough off of the ground to allow wildlife movements while ensuring an adequate barrier to livestock. This can be a fine balance when grazing mixed herds of cattle and sheep. In the Black Hills and several western SD counties, elk conflicts with fences can be a major concern, especially when fences are placed in primary seasonal migration corridors. High visibility fence or fence constructed to allow elk ease of movement can minimize fence damage and wildlife injury.

Some producers have adopted methods to remove or put down fences during spring and fall migrations, allowing elk or pronghorn to move freely across pastures with minimal negative impacts to the animals or the fence. Smooth wire is also preferred over barbed, as it tends not to wrap or snag legs and vegetation (Figure 8).

In Minnesota, wildlife managers are experimenting with high-tensile wire on new conservation grazing projects. These systems incorporate three-strand high-tensile wire that is only tensioned enough to avoid sagging in the wire. Posts are placed roughly 45 ft. apart. The lower tension not only minimizes impacts from snow load and deer impacts, it also prevents unnecessary pressure on springs and corners resulting from line contraction in cold weather (Figure 9).

Finally, simply leaving gates open can be an effective strategy to reduce wildlife injury if those gates are near areas where wildlife generally concentrate movements. See "A Landowner's Guide to Wildlife Friendly Fences" (Paige 2008) in the resources and web links section at the end of this chapter for excellent ideas related to wildlife friendly fencing. http://www.mdt.mt.gov/publications/docs/brochures/friendlyfences.pdf

Figure 8: Issues with fence damage and elk mortalities (left) led ranchers near Crawford, Nebraska to install a fence let-down system. Removable pins (large fence staples) (right) allow managers to easily move smooth (non-barbed) wire up or down. Leaving gates open has proven effective in reducing wildlife injury, fence damage, and maintenance labor. Smooth wire can provide an effective deterrent to livestock provided that forage availability is adequate so livestock are not forced to pressure the fence and reach for forage outside the pasture. *Photos by Curtis and Wade Anderson*

Figure 9: The author displays a three-strand high tensile perimeter fence designed for livestock and wildlife movement. Wire tension is kept low with 45 ft. post spacing to minimize impacts to deer and grouse. The bottom wire is maintained approximately 20" above the ground. Additional wires were installed at 12" intervals. All wires are insulated for ease of adjusting which wires are energized 'hot' and which serve as ground or 'cold' wires. Note the game trail passing through the fence line. Managers have witnessed deer slip easily underneath and through the fence on many occasions without injury and without damage to fence insulators. Photo by Joe Blastick.

References

Butler, L.D., J.B. Cropper, R.H. Johnson, A.J. Norman, G.L. Peacock, P.L. Shaver, and K.E. Spaeth. 1997. National range and pasture handbook. United States Department of Agriculture. Natural Resources Conservation Service, Grazing Lands Technology Institute, Fort Worth, TX. 190-vi-NRPH, September 1997. Revised 2003. http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/landuse/rangepasture/?cid=stelprdb1043084 or http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17734.wba

Nichols, James T. 1981. G81-581 Cross Fences for Pastures Under Center Pivot Irrigation. Historical Materials from University of Nebraska-Lincoln Extension. Paper 716. http://digitalcommons.unl.edu/extensionhist/716

Paige, C. 2008. A Landowner's Guide to Wildlife Friendly Fences. Landowner/Wildlife Resource Program, Montana Fish, Wildlife and Parks, Helena, MT. 44 pp. http://www.mdt.mt.gov/publications/docs/brochures/friendlyfences.pdf

Quigley, T.M., H.R. Sanderson, A.R. Tiedemann, and M.L. McInnis. 1990. Livestock Control with Electrical and Audio Stimulation. Rangelands. 12(3):152-155.

Volesky, J.D., F. de. Achaval O'Farrell, W.C. Ellis, M.M. Kothmann, F.P. Horn, W.A. Phillips, and S.W. Coleman. 1994. A Comparison of Frontal, Continuous, and Rotation Grazing Systems. Journal of Range Management. 47:210-214.

Volesky, J.D. and J.J. Nichols. 2006. Fences and livestock water for pastures under center pivot irrigation. University of Nebraska, Lincoln Extension, Institute of Agriculture and Natural Resources. G581 (revised june 2006). 4 pp. http://drought.unl.edu/portals/2/Documents/DuringDrought/g581fenceswaterirrigatedpasture.pdf

Range Plant References

Johnson, J.R. and G.E. Larson. 2007. Grassland Plants of South Dakota and the Northern Great Plains: a Field Guide with Color Photographs. 288 pp. South Dakota State University. Brookings, SD.

Sedivec, K.K., D.A. Tober, W.L. Duckwitz, D.D. Dewald, and J.L. Printz. 2007. Grasses for the Northern Plains Growth Patterns, Forage Characteristics and Wildlife Values: Volume I - Cool-season. Circ. R-1323, North Dakota State University Extension Service, Fargo, ND. 90 pp.

Sedivec, K.K., D.A. Tober, W.L. Duckwitz, D.D. Dewald, J.L. Printz, and D.J. Craig. 2009. Grasses for the Northern Plains Growth Patterns, Forage Characteristics and Wildlife Values: Volume II - Warm-season. Circ. R-1390, North Dakota State University Extension Service, Fargo, ND. 68 pp.

South Dakota Department of Agriculture. 2009. South Dakota Weeds. 235 pp. South Dakota Department of Agriculture. Pierre, SD.

USDA/NRCS Plants database. http://plants.usda.gov/java/