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Conservation Planning with Bison Producers

Acknowledgments

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Cover Photo

Photo 1: Bison. Hailey Frost, Field Biologist, Texas NRCS.

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Contents

Purpose

Bison production and bison operations are increasing across the United States. Consumer demand, economic viability, conservation efforts, and support from organizations and agencies are helping to grow the industry.

This technical note is designed to assist NRCS planners and partners collaborating with bison producers. It introduces key terminology and concepts and provides considerations for developing conservation plans and implementing conservation practices for bison. Drawing on a wealth of existing technical documents, research literature, insights from bison stakeholders, and practical experience, this technical note serves as a quick guide for NRCS field offices.

This technical note can also inform producers and raise awareness of available NRCS assistance, and hopes to foster continued collaboration, knowledge exchange, and technical advancements in sustainable practices for bison producers and their industry. To ensure it provides the most current guidance and best available science, this technical note will undergo periodic reviews.

Foreword

Photo 2: Bison. Johnathan Fettig, State Range Specialist, North Dakota NRCS.

A New Day for Bison. A conservation success story.

“Standing in this space in this moment”-L. Whitman

NRCS extends its heartfelt gratitude to the numerous contributors to this technical note, both inside and outside the agency. We especially thank our partners, Lydia Whitman of the National Bison Association (NBA) and Dr. Jeff Martin of the South Dakota State University Center of Excellence for Bison Studies, for their collaboration, expertise, and passion. We look forward to many more years of partnership.

Photo 3: South Dakota State University Center of Excellence for Bison Studies.

Introduction

Bison (*bison bison*) are the largest indigenous, free-ranging ruminants in North America (Canada, 2017). Their recovery is a true conservation success story. Before 1900, there were an estimated 30-60 million bison roaming across North America; however, by the end of that century, hunting had taken bison to near extinction with less than 1,000 remaining. Dedicated conservation efforts, including the establishment of protected areas and sustainable management practices, brought the bison back, highlighting the remarkable recovery and resiliency of this iconic species.

Currently, there are over 192,000 bison in the United States residing on almost 2,000 private ranches and farms according to the 2022 USDA Agricultural Census (Matheson and Whitman, 2022). Approximately 11,000 bison are in U.S. federal herds (Theodore, 2020), 10,000 are in state and other public herds, and an estimated 30,000 are on tribal lands (Martin et al., 2021). The total in North America today is approximately 400,000 head among the United States, Canada, and Mexico (Matheson and Whitman, 2022).

Bison on the Rise

Bison operations are increasing for a variety of reasons, including economic opportunities available in niche meat markets, consumer demand for leaner red meat, interest in value-added products such as skulls, hides, and horns, and opportunities in tourism and hunting enterprises.

Bison can provide economic advantages in reducing operation costs compared to other livestock, after initial set up. Bison are primarily grass-fed and generally require less supplemental feed. They need less handling with no branding, castration, or de-horning. Being adapted to a wide range of climate, bison survive in extreme weather without requiring shelter or housing. They also experience fewer calving difficulties, need less assistance calving, and generally have lower calving death rates.

The number of bison operations are also on the rise as producers associate ecological benefits of bison to grazing on native grasslands. In some cases, bison have been prized for not being genetically modified or domesticated solely for production purposes. They have been regarded as the prairie’s ecological engineers by some and have been associated with “rewilding” efforts that aim to restore grassland biodiversity by reintroducing native megafauna (Ratajczak et al., 2022).

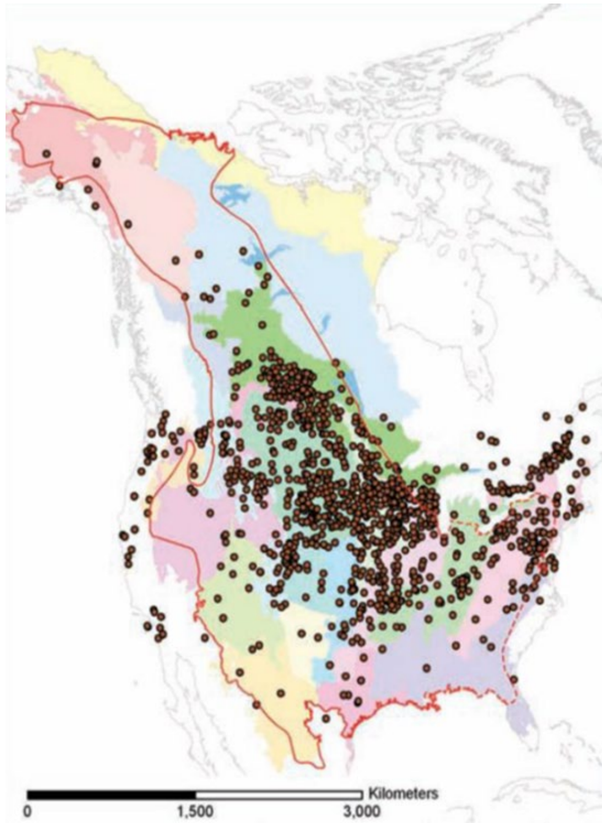


Illustration 1: Current extent of bison operations across the North American Continent, USDA.

Bison Physiology and Nutrition

Bison, like cattle, are grazing ruminants with four-chambered stomachs. They consume a diverse range of forages, some of which may be less palatable to cattle (Martin and Brooke, 2023). Bison graze approximately 4 to 9 hours per day, less than cattle who can graze 8-12 hours per day (Feist, 1998; CBA, 2017; Parker, 2017), however, the bison Animal Unit Equivalency (AUE) is the same as beef cattle with a 1,000-pound bison cow considered one animal unit (AU). Dry matter intake (DMI) is estimated at 2.6% of body weight, which translates to around 26 pounds of DMI needed daily for each bison cow. While DMI may decrease slightly during winter months, it is advisable to plan for 2.6% DMI per animal year-round (Bauman, 2023). Remember that DMI refers to feed without water or moisture, and intake can vary based on the nutrient density of available forages (Bauman, 2023).

The water requirements of bison depend on several factors, including DMI, the bison's physiological status, age, environment, and management. As a general guideline, and based on scientific estimates, bison typically need 10-15 gallons of water per day per animal (Kirk Baer, 2024; CBA, 2017; Parker, 2017). For more details, refer to the section on bison Water Facilities on page 26.

Bison have somewhat higher populations of cellulolytic (fiber-digesting) bacteria than cattle, thus requiring additional energy and nitrogen that is most likely supplied by the higher available energy obtained from prolonged dry matter digestion and by their efficient system for recycling endogenous nitrogen (CBA, 2017; Parker, 2017). It takes about 80 hours for grass to pass through their digestive systems, allowing nutrients to be absorbed during this extended time and enabling bison to live on lower nutritional quality forages (U.S. NPS, 2015).

Bison saliva is 30% higher in nitrogen than cattle, and bison serum (the liquid component of blood) is 38% higher in urea than cattle but does not differ in urine urea levels. This urea conservation in bison contributes to higher levels of urea nitrogen for microbial growth (CBA, 2017; Parker, 2017). See the Biological and Hematological Parameters in American Bison from the NBA for more information.

Photo 4: South Dakota NRCS.

Bison weight and condition fluctuate seasonally. They gain weight in summer and fall to prepare for winter, when they can experience metabolic down regulation, leading to weight losses of up to 10-15% of their body weight. Once bison reach 18 months old, they begin a lifetime cycle of winter weight loss directly related to daylength. Daylength affects the pineal gland near the base of the brain and the secretion of melatonin, which inhibits growth hormones that are responsible for metabolic rates (Saskatchewan, 1999).

The difference between cattle and bison is that cattle are consistently gaining body weight from birth to about 30 months of age. During this time, cattle experience phases of rapid growth, which include increases in frame size, muscle mass, and organ development. These phases are followed by periods of slower growth, primarily in muscle mass, and eventually a phase of fat deposition (Parker, 2017). Bison, on the other hand, are affected by this metabolic down regulation that starts at about 18 months. Up until 18 months, their growth patterns are like cattle, but after 18 months, they experience static or negative growth during the winter (Parker, 2017).

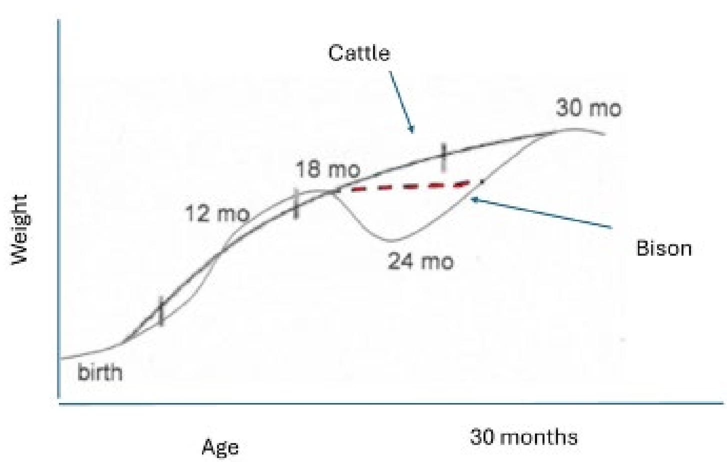


Illustration 2: Cattle and bison metabolic rates. Parker, 2017.

Parker, DVM (2017) offers a metabolic profile comparison (graph condensed by Simpson, 2024) between cattle and bison. See Bison Basic Nutrition by the Saskatchewan government for more information.

Bison can display behaviors to conserve energy and body heat in the winter, such as reducing movement to minimize disturbance to their insulative coats, maintaining slower heart rates and slower breathing to reduce cold intake, and minimizing overall metabolic activity (Bauman, 2023). Ensuring bison start the winter with sufficient fat reserves and body condition is important.

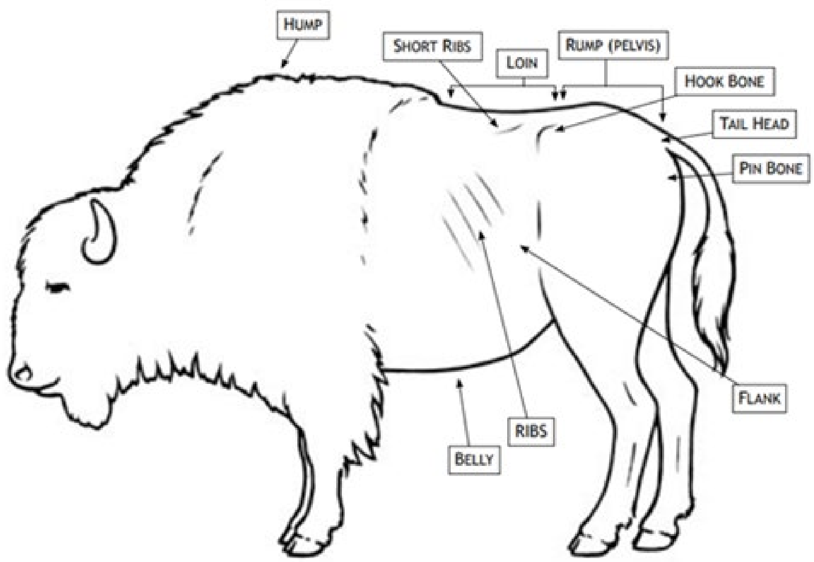


Illustration 3: What's the Score? Canada, 2017.

Body condition refers to the amount of fat that an animal carries, and Body Condition Scoring is a systematic technique to estimate fat on the animal (Government of Alberta, 2019).

Time of Year	Ideal Score	Range
November	4	3-4+
April	2+	2-3
July	3+	3-3+

Table 1: Bison body condition scoring. South Dakota NRCS.

Table 1 provides recommended body condition scores for bison during different seasons of the year. See What's the Score: Bison – Body Condition Scoring (BCS) Guide by the Government of Alberta and Grazingland Animal Nutrition Laboratory by Texas A&M University for more information on how to score bison body composition.

Maintaining adequate condition during the winter is important. When animals remain in good condition, any weight lost during the winter can be recovered in the spring through compensatory gain, provided there is adequate forage (CBA, 2017; Parker 2017). Conversely, managing for leaner bison in the spring can help reduce excess fat, which may contribute to calving problems (Government of Alberta, 2019). See the Center of Excellence for Bison Studies by South Dakota State University for more information about winter bison management.

Photo 5: Bison BCS 4, Bison. Frank McAllister, Canada, 2017.

Monitoring bison wellness and weight loss is crucial year-round and aligning stocking rates with the grazing unit's carrying capacity can minimize the need for supplemental feeds and promote positive pasture conditions.

Stocking rate refers to the number of specific kinds and classes of animals grazing or utilizing a unit of land for a specific period. Stocking rate is an important management decision for the operation and may have the largest health and productivity impact on animal performance and condition of the grazing unit. Stocking rates may be expressed as animals per acre, hectare, or section, or the reciprocal (area of land/animal). When dual use is practiced (e.g., cattle and sheep), stocking rate is often expressed as animal units per unit of land or the reciprocal (USDA, 2022).

Carrying capacity is the average number of livestock and wildlife a grazing unit can sustain. It is determined by the amount of annual forage produced in the unit and its availability to the animal. For example, on many rangelands, the carrying capacity may be less than forage production if parts of the grazing unit are inaccessible to the animals. Carrying capacities can also reflect the unit's management objectives. See the National Range and Pasture Handbook (NRPH) for more information about stocking rates (Subpart F) and carrying capacity (Subpart E).

Photo 6: South Dakota NRCS.

Lifecycle

Bison cows may live 15-20 years in the wild and 25 years in captivity with bulls living up to 15 years in both the wild and in captivity. Bison cows begin reproducing around 2-3 years old and will give birth to one calf after a gestation period of 270-293 days, with an average of 277 days (cattle average gestation is 285 days). Adequate nutrition and body condition are important for bison cows to successfully raise calves and reproduce the following year.

Calves are born weighing between 40 and 50 pounds and will nurse for the first 7-8 months, with weaning before the end of their first year. Males reach breeding maturity between 3-4 years of age (NPS, 2023) and will join the herd during the rut or breeding season.

The rut usually occurs between late July and August but will vary geographically, with southern regions earlier in the season compared to northern regions (Miller, 2002).

Bison are usually harvested between 20-30 months old, while cattle are harvested at 18 months old (Martin and Brooke, 2023). See Code of Practice for the Care and Handling of Bison by the National Farm Animal Care Council for more information on harvesting.

Behavior

Bison retain many wild traits that include large flight zone distances, short tempers, and minimal domestication behaviors (Martin and Brooke, 2023). They need adequate space. Crowding animals into corrals or working pens leads to conflict, especially between bulls or those outside the family unit.

Photo 7: Horse-bison altercation. Dusty Jager, Grazing Specialist, NRCS.

Bison may injure other animals or other classes of livestock that come into close contact or share the same grazing unit during the same time. As a rule, expect bison to behave more like wildlife than domesticated livestock (Martin and Brooke, 2023). Under stress, bison might pant, raise their tails, and in extreme cases, lie down, faint, or stop breathing. Defensive behaviors include snorting, bellowing, holding their tails upright, pawing the ground, and executing bluff or real charges (Martin and Brooke, 2023).

Photo 8: Sutures and drains. Dusty Jager, Grazing Specialist, NRCS.

Wallowing is another distinctive characteristic of bison. They will wallow to help shed their winter coat and to help mitigate biting insects and other skin irritants with dust baths. Wallowing is also a behavior by males during the mating season to leave scent markings and display dominance. Males will sometimes urinate in the wallowed areas before rolling to advertise their physical condition to other males (U.S. NPS, 2016b). For more information on wallows, see the Ecosystem Services section on page 30.

Literature suggests that bison can spend a substantial amount of time in non-feeding activities, especially during the rut, but also in play, aggression, defense, and grooming behaviors (Canadian, 2022).

Photo 9: Bison wallowing. M. Chavez, Wichita Mountains Wildlife Refuge (U.S. NPS, 2016b).

Grazing Considerations

Conservation Practice Standard (CPS) 528 – Prescribed Grazing is NRCS's practice that manages the harvest of vegetation with grazing and browsing animals to achieve specific ecological, economic, and management objectives. This practice is applicable to all lands where grazing and browsing occur and may help bison producers identify purposes and steps to develop a grazing management plan for their operation.

While there is no universal best grazing system and each client should customize their grazing plan to address specific resources and goals of the operation, some key items apply to the plans and specifications section of the standard. These include:

- Identifying the client's goals and objectives.
- Mapping the planned grazing units with existing and relevant infrastructure.
- Inventorying the current and planned forage.
- Assessing livestock and wildlife forage demand.
- Developing a feed and forage balance by grazing unit.
- Developing a detailed grazing strategy that specifies intensity, timing, duration, and frequency of use within each unit.

Each client should have a contingency plan to guide adaptive management decisions that help mitigate impacts from episodic or unexpected events, such as drought, fire, and flooding. They should use monitoring protocols to help identify if the plan addresses the producer's goals and objectives and to ensure that grazing units are maintained in an upward trend. See Conservation Practice Standards – Prescribed Grazing (528) for more information.

Some basic types of grazing strategies include deferred rotation, rest rotation, high-intensity-low-frequency, short duration, and adaptive grazing. While no one system fits all operations, being flexible and adaptable to changing conditions within any system helps producers reach their goals even during less than favorable years. Rigid application of any grazing system is rarely successful (Briske, 2011).

Refer to Subpart F, "Management of Grazing Lands," of the NRPH for more information.

Year One

Mgt. unit	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
1	no	no	graze	graze	graze	graze	graze	graze	graze	graze	graze	graze
2	graze	graze	no	no	no	no	graze	graze	graze	graze	graze	graze
3	graze	graze	graze	graze	graze	graze	no	no	no	no	graze	graze
4	graze	graze	graze	graze	graze	graze	graze	graze	graze	graze	no	no

Year Two

Mgt. Unit	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
1	graze	graze	no	no	no	no	graze	graze	graze	graze	graze	graze
2	graze	graze	graze	graze	graze	graze	no	no	no	no	graze	graze
3	graze	graze	graze	graze	graze	graze	graze	graze	graze	graze	no	no
4	no	no	graze	graze	graze	graze	graze	graze	graze	graze	graze	graze

Table 2: Example of a two-year deferred rotation grazing strategy. USDA, 2022.

Bison are naturally migratory animals, daily walking at least five times further than beef cattle. Therefore, some producers have found it beneficial to design grazing systems that enable and mimic this migratory desire either by having movement available within larger grazing units or rotating through multiple units, which can also help reduce stress and keep bison content. Important considerations for conservationists before planning a bison grazing system are to consider the rut, period of calving, social group requirements, animals involved, preferred areas of grazing units during seasons within the year, and other herd behaviors (Miller, 2002). These influences have a strong effect on the management, movement, and ease of movement of the herd.

Research literature provides some differences between bison and cattle in grazing preferences and landscape use for consideration in grazing plans. Bison will travel across the landscape following grazing preferences to maximize forage quality (Knapp et al., 1999; Nippert et al., 2013). Not only do bison move more frequently than cattle, but they will also travel greater distances while grazing (Miller, 2002). Bison graze more uniformly, in higher intensity, and in lower duration than cattle. Because they graze in large, denser groups, their grazing can create mosaics of differing grazing heights creating heterogeneity within the plant community. These mosaics can be important to other species (Geremia et al., 2019).

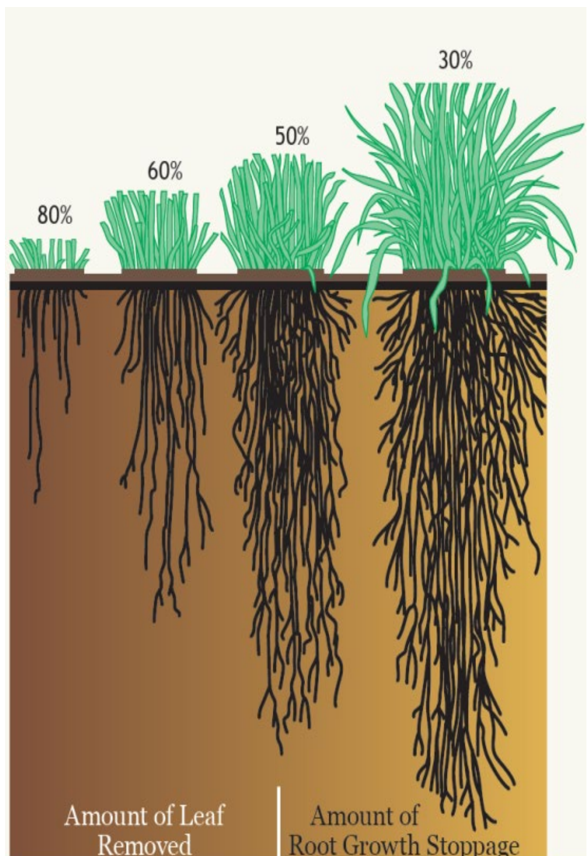
Several morphological adaptations help bison travel and graze, including the high shoulder hump and lower hind quarters that facilitate their energy efficient cantering gate (Guthrie, 1980). Although bison are not exceptionally fast (speeds to 35 mph), their structural form enables frequent long-distance movement.

Photo 10: Bison running on the Konza Prairie. Brenda Simpson, National Grazing Team, NRCS.

Bison have migratory tendencies in large areas or grazing units (ITBC, 2015) and utilize forages efficiently while spending less time grazing (Miller, 2002). Kohl et al. (2013) found in a study on the American Prairie Reserve in Montana and the Grasslands National Park in Saskatchewan, that cattle spent 45-49% of their time grazing as compared to 26-28% of time bison spent grazing. In two studies by Peden and Norland (1974 and 1984), it was noted that bison appeared to prefer drier forage and spent less time in swales and depressions where soil moisture was higher.

Bison forage preferences differ from cattle in that they tend to select grasses and sedges over forbs while cattle are more likely to mix their diets among grasses, forbs, and shrubs. Bison forage preferences also differ from cattle in that they vary their dietary selection through the seasons, preferring grasses during summer and winter, and then selecting legumes and forbs during the spring and fall. This is primarily driven by their desire to seek lipids and carbohydrates (i.e., energy) in the spring and fall to recuperate from calving and from the rut, respectively (Bergmann et al., 2015; Craine, J.M., 2021; Hecker et al., 2021). Because they prefer grasses over other vegetation during the summer growing season, ensuring proper grazing use and adequate residual stubble heights on desirable grasses or key species is important.

Key species are forage species that serve as an indicator of the degree of use within the grazing unit and should be important forage to the specific grazing animal of the operation. Monitoring these species in key areas can help inform management decisions, and key grazing areas should be selected for their location and use or value as a grazing monitoring point. Refer to Subpart F, "Management of Grazing Lands," of the NRPH for more information.



Amount of Leaf Removed	Amount of Root Growth Stoppage
10–40%	0%
50%	2–4%
60%	50%
70%	78%
80–90%	100%

Illustration 4: Plant root response to grazing by the percentage of leave material removed. USDA, 2016.

In northern Colorado, Peden and Hansen (1974) found that bison spent less time near water and only watered once a day. Similarly, Norland (1984) reported that bison would go to water once a day, and the length of stay at watering areas was "short duration–one hour or less for even the largest herds." Nippert et al. (2013) found most bison utilized rain-fed puddles and wallows over perennial streams on the Konza Prairie Biological Station in Kansas. One possible theory for the short stays bison exhibit at watering sources is evolved behavior to avoid or minimize predator encounters.

Cattle, on the other hand, have differences in water use and display a marked preference for moister forage. Pinchak and colleagues (1991) reported that 77% of the observations of cattle grazing foothill ranges in Wyoming were within 366 meters of water, and Smith et al. (1992) noted that most of the use was on wetlands or sub-irrigated, level sites. Similarly, Smith et al. (1992) found that cattle selected a higher percentage of floodplain habitat and a lower percentage of upland habitat than these habitat types represented in their study area.

Peden and Hansen (1974) also noted that bison selected rougher, less digestible forage, which may give them a competitive advantage on native grasslands where forage quality varies seasonally.

A comparison of digestion among domestic cattle, bison, and Tibetan yak (Schaefer et al., 1978) found that bison retained forage in their digestive tract longer, and, therefore, had a greater ability to digest fibrous feed material, resulting in higher nitrogen intakes. This may be one reason that bison can survive and persist on ranges with little or no supplemental feed.

Photo 11: Bison pasture with a poly wire electric gate, high intensity grazing system with 5-day rotation. Tracy Boll, North Dakota NRCS.

Infrastructure

In designing grazing systems, fences, watering locations, water storage, and grazing unit size are important considerations. But the most important factor to keep bison in a location is to provide them with all the resources they need, including adequate forage, water, space, and family. When their needs are met, the desire to test infrastructure, such as fences, significantly diminishes. Anecdotally, total herd sizes greater than 30 individuals remain more calm than smaller herds (Martin and Brooke, 2023).

Bison form matriarchal family groups with herds typically made up of females and their offspring. Young males may reside within the herd, but adult males will only join the herd temporarily during the rut or breeding season. Bison have strong social hierarchy with multiple layers of dominance. Adequate space is necessary to reduce competition, which helps minimize infrastructure damage (Bauman, 2023).

The optimum size of pastures varies based on several factors, including herd size. Larger grazing units, aligned within the goals of the operation, result in less stress for bison. Bison infrastructure must be more robust than that for domestic livestock, with considerations for adequate space to facilitate the natural pecking order in herds. Further, if bison are in adjoining grazing units, one herd may try to join with the other, which increases the pressure on barriers, including fence exponentially (Miller, 2002).

Fence

CPS 382 – Fence can be used to provide a means to control the movement of animals to accomplish specific conservation objectives. This practice applies to any land that needs animal management. Specific designs and implementation requirements vary according to site locations, the level of security needed, and other site-specific factors. For more specific design requirements, consult your state's grazing technical lead or State Resource Conservationist. Table 3 provides heights and wire requirements found to be effective for bison exterior or critical containment fences.

Type	# Strands	Top Height	Comments
High tensile smooth wire with electrical in-ward facing standoffs or offsets	5-8 strands with 2-4 strands electrified	60″-66″	Consider adding wildlife-friendly features, especially in wildlife corridors.
Barbed wire (adding an electric hotwire inside has been found to be beneficial)	4-6 strands	42″-72″	Consider adding wildlife-friendly features, especially in wildlife corridors and especially at taller top strand heights. 18″ or greater space is recommended from soil surface to the bottom wire.
Net wire with barbed wire on top	48″ net wire with 2 strands of barbed wire on top	60″-75″	Note: This fence design rates high for being non-friendly to wildlife. Consider adding wildlife-friendly features, especially in wildlife corridors.
Net wire exclusion		75″-96″	Recommend use only in critical containment areas, such as near high traffic or high development areas.

Table 3: Exterior or boundary fence designs found to be effective for bison (critical containment). NRCS.

Consult the NRCS State Resource Conservationist or State Grazing Specialist in your state for more information on fencing standards and specifications. Some states have developed state-specific requirements.

This technical note does not supersede state guidance, State Standards, State Specifications, or State Implementation Requirements (Designs) for fence.

Fences should be most secure in areas where grazing units are next to transportation corridors, urban or suburban areas, or other attractants, such as hay or crop fields (Gates, 2006).

Effective bison fences can be constructed from multi-strand barbed wire, smooth wire, woven wire, electric fence, or a combination of these types. Generally, a taller more robust fence is needed for bison perimeter or boundary fences (Frasier, 2023; Hamilton et al., 2023). The general rule of thumb for bison fence is to keep the wire height at eye level to the bison (5-5.5 feet) (Martin and Brooke, 2023).

See illustration 5 for a wildlife-mitigated barbed wire bison fence on page 20.

Most bison fence designs recommend setting a wood or pipe post in concrete or similar strength every 60-100 feet with T-posts in between set at 15-16.5 feet apart. Post material selection should consider fire frequency. In areas where burning is common, pipe and steel posts may be preferred.

Fences considered to be wildlife exclusion fences (i.e., net wire at 96 inches high) should be limited in use to areas with high-security needs.

More information on CPS 382 – Fence can be found in your state’s Field Office Technical Guide or in the USDA National Standard Document.

Photo 12: Elk looking for escape from a high fence during wildfire. NRCS.

Internal fences, cross fences, or other areas of non-critical containment can be constructed using lower fence heights, fewer wires, and more considerations of ease of movement and safety for other wildlife species.

Grazing lands provide important habitat to a diversity of wildlife species, and fences can act as partial or complete barriers to movement and migration of wildlife. Fences can also entangle big game and cause impacts and injuries to numerous species, including birds. In short, fences should address the operation needs while remaining as wildlife friendly as possible.

Fences should be constructed in high-visibility locations, avoiding areas with dense trees and areas known for wildlife travel routes or corridors. Considerations that can help increase wildlife navigation are to leave gates open when pastures are not in use, add more gates within the fence line, install sections of let-down fences, or install sections of fence that have adjustable wire spacing and heights. Distance between gates or sections of let-down or adjustable fence should be less than ¼ mile apart. See fence designs for let-down and adjustable wire fence drawings. Fence heights may be adjusted to fit the operational needs.

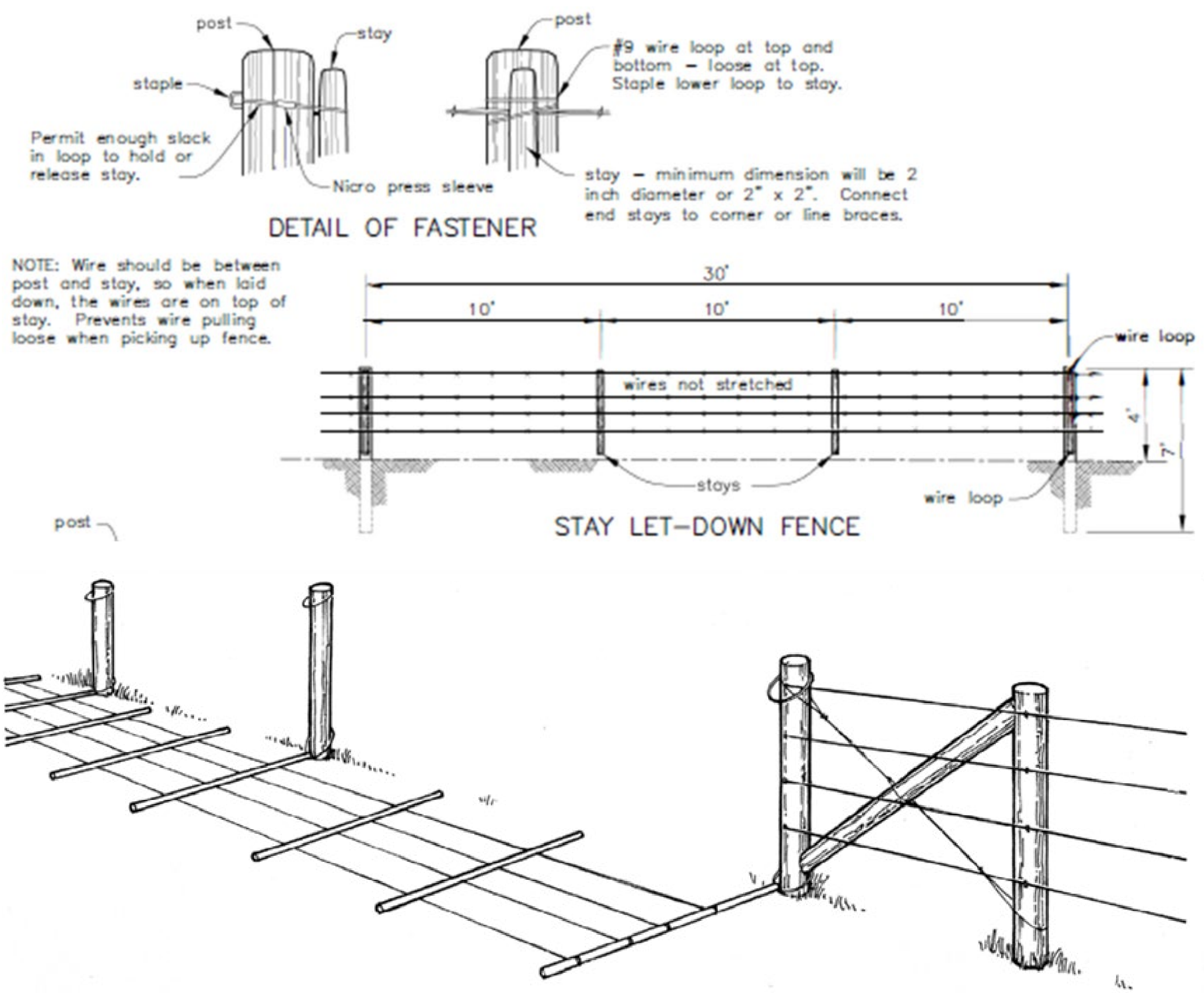


Illustration 5: Stay let-down fence and adjustable wire fence drawings. Alaska and South Dakota NRCS.

Stay let-down fences utilize sections of unstretched fence that have been attached to posts using stays and wire loops. The loops allow the stays to be laid down when not in use. This type of fence can also be used in areas of heavy snow load to reduce damage on fences. This option can be used with barbed, smooth, or woven wire fence designs.

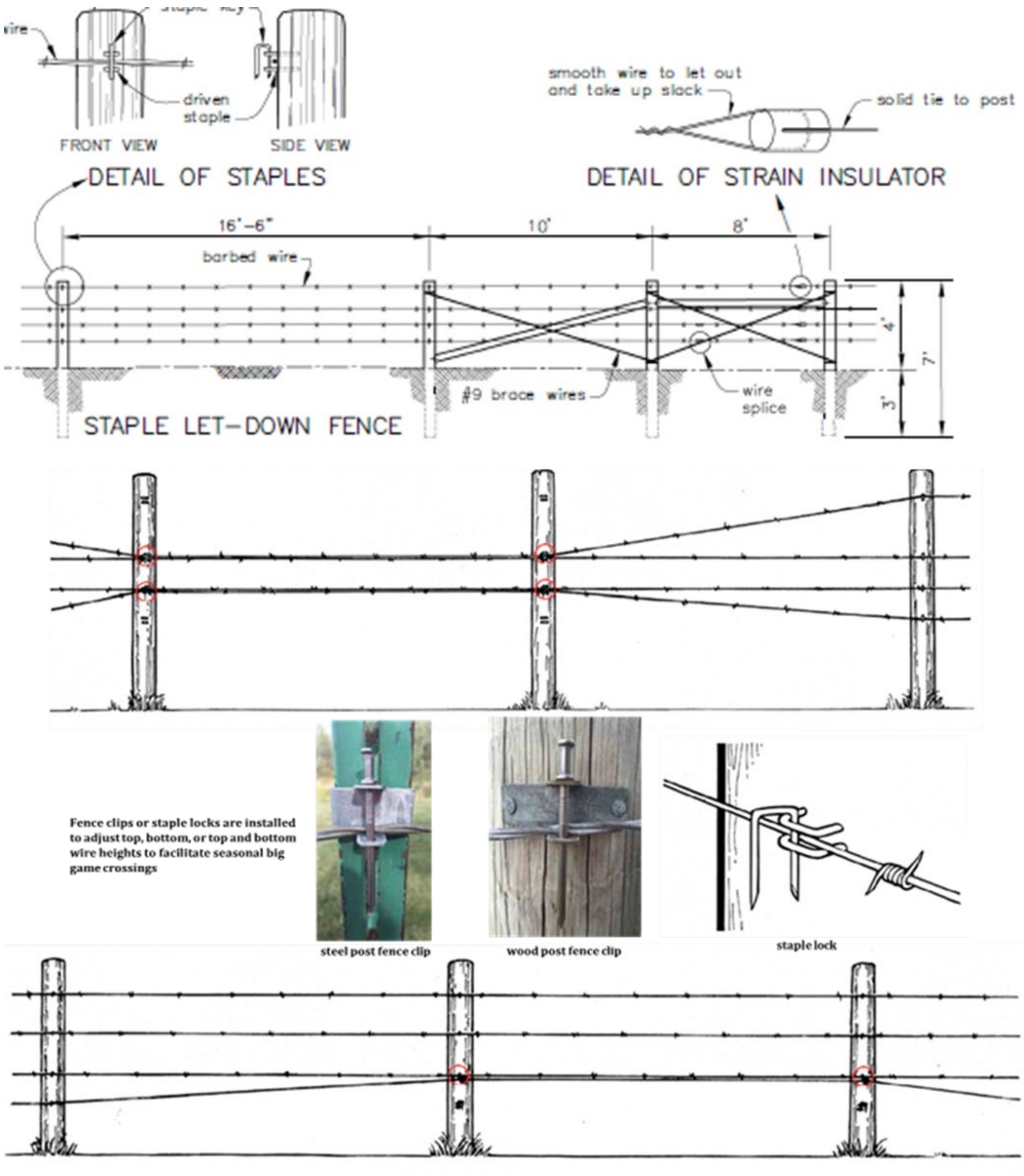


Illustration 6: Staple let-down fence or adjustable wire fence. Alaska and South Dakota NRCS.

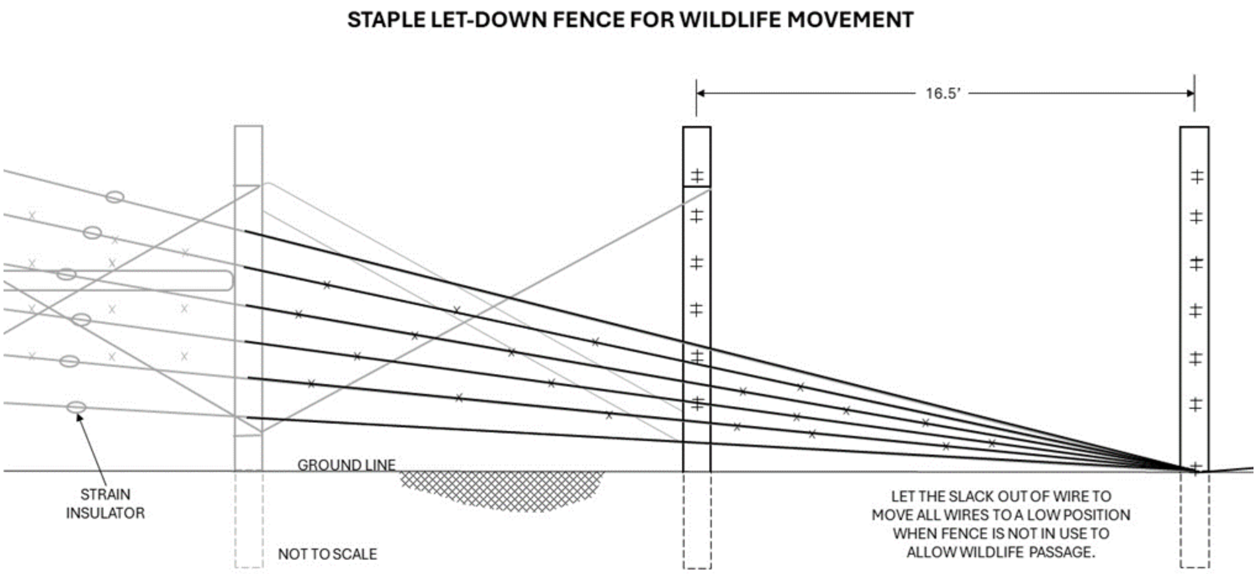


Illustration 7: Staple let-down fence for wildlife movement. Alaska and South Dakota NRCS.

The staple let-down fence incorporates sections of fence that can be moved to a low position by letting slack out of each of the wires temporarily. The slack can be moderated by splicing in a strain insulator with smooth wire near an in-line or corner brace. Depending on the species of wildlife, all wires can be moved down to allow easy passage or can adjust top wires down or bottom wires up.

This design incorporates a "staple key" or sometimes a "staple lock," where two staples are driven into the post, and another is placed perpendicular to those staples to attach the wire to the post (see inset). Some manufacturers make specialized let-down clips that fit on steel T-posts. This option is most effectively used with barbed or smooth fence designs.

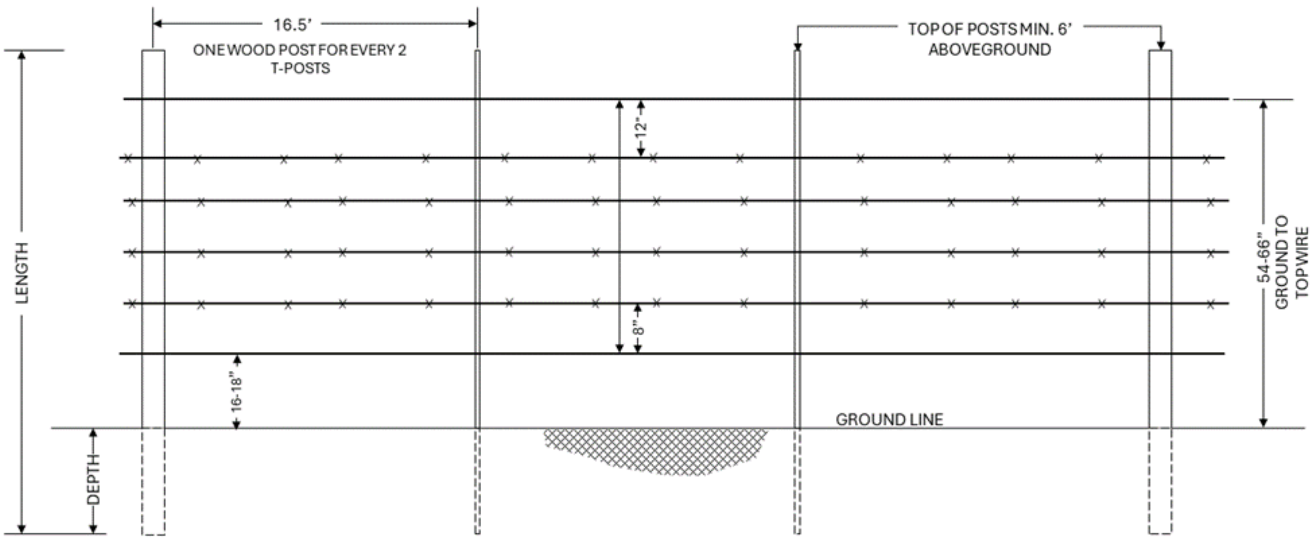


Illustration 8: Wildlife-mitigated barbed wire bison fence. Bottom wire height recommendation is 18" or greater, but no less than 16".

Electric fence is also an option for wildlife-friendly interior fences that work well with bison. Electric fence can be moved or adjusted with less effort than permanent wire types and has been found to be effective in managing cattle and bison while allowing elk, deer, and pronghorn to easily cross (Karhu and Anderson, 2006). They found that 3-wire electric fence made with 12.5 gauge high-tensile wire may be the most effective in areas with bison at wire heights of 22" hot, 32" ground, and 42" hot.

Photo 13: Single strand hot wire interior fence. John Halstead, 2024.

Finally, consider placing fences in areas that make sense to bison, which could be different than what makes sense to humans. Watching behavior and travel patterns before building permanent fences can increase ease of movement while saving money, effort, maintenance, and frustration in the long run (Halstead, 2024).

For more information on wildlife-friendly fences, see NRCS's Technical Note 190-BIO-93.

For more information on wildlife-friendly features, including slip gates, X-wire gates, and sliding rail gate designs that could improve wildlife passage while holding bison, see Wildlife Crossing Gates – Structures and Designs.

If an operation is transitioning into bison production, a control grazing unit or trap should be considered to help secure bison during the introduction and acclimation phase to their new surroundings. The control grazing unit should be smaller in size, located in an area to reduce motivation to escape, and have increased strength in its fence design with added precautions. The acclimation phase varies with animals and conditions but should not be less than 14 days (Frasier, 2023).

Bison are excellent swimmers; therefore, water bodies are not effective barriers and will not provide secure boundaries. Water gaps and geographic barriers will also hold cattle differently than bison. Bison are also known to traverse steep and rugged terrain that may deter cattle. Bison are also curious and will investigate and potentially cause damage to existing infrastructure. For example, consider fastening water gap structures instead of leaving them swing to help deter a bison's curiosity and avoid potential damage (Frasier, 2023).

When considering cattle guards in a bison boundary fence, a double-width cattle guard or "Texas gate" with gates across the structure are recommended. Bison have been known to cross standard cattle guards. A recommended width is no less than 16 feet wide with fences on each side of the structure. The spacing between pipes should be 7-8 inches, which will deter bison from attempting to cross but allow them to pull their legs out if they do step between the rails (Gates, 2006). Also, consider using rounded pipe rails for cattle guard construction (NBA, 2024). Success has been found in painting every third rail of the guard white to give the rail spacing the perception of greater distance (NBA, 2024).

A consideration with cattle guards in areas of high snow load is to allow adequate depth in the cattle guard pits underneath, so that the snow does not build up and acts as a base with which the animals can cross.

Wire fences are not recommended in areas where handling or shipping pressure occurs. See Corrals and Handling Facility section on page 25 for more information.

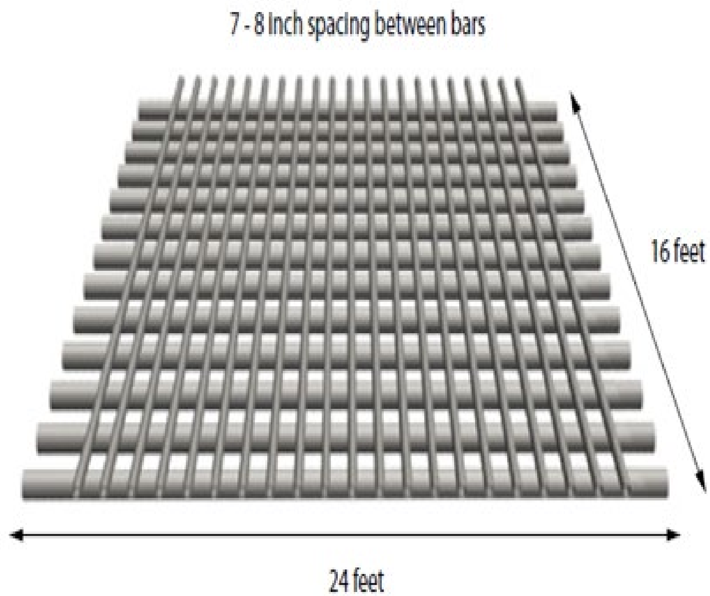


Illustration 9: Cattle guard designed for bison (Texas gate) based on specifications provided by N. Cool and W. Olson. Elk Island National Park and Mark Kossler, Flying D Ranch, Bozeman, MT, Gates, 2006.

Photo 14: Bison cattle guard with gates. Stuart Schrag.

Corrals and Handling Facilities

Bison require working facilities that account for their agility and flight or fight response and are designed for worker safety (NBA, 2024). Components of handling facilities are like working cattle and include a catch pen, cutting or sorting pens, crowding alley, scale, squeeze chute, and load out areas. The differences for working bison are that recommended corral heights range between 6’6”-7’ tall and have solid sidewalls to keep bison from seeing workers and reducing animal stress and injury (ITBC, 2015). Many publications recommend crash gates along with the squeeze chute.

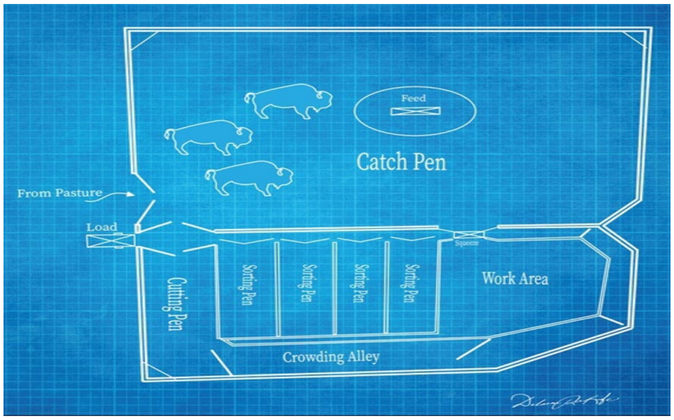


Illustration 10: Basic corral design specific to bison. Intertribal Buffalo Council, 2015.

Crash gates are designed to control and direct bison into position easier and safer in the chute and to avoid injuries while increasing handling efficiency. Crash gates can be designed to reduce visibility and perceive threats with the intent to reduce stress and create a calmer environment in the chute.

Low stress handling procedures are important for working or moving bison. Bison are herd-oriented animals and working bison in small groups has been found to be beneficial (ITBC, 2015). Several resources are available to provide guidance for using Low Stress Bison Handling Techniques, such as the Stockmanship Journal.

More information and details for handling facilities can be found at:

- Bison Behavioral Management and Handling Facilities Design - NBA
- Transitioning from Cattle to Bison: An Introduction
  - This producer handbook provides an illustrated corral design specific to bison, as shown in Illustration 10.
- The Bison Producer Handbook from the NBA.
  - Free on the member's website or for purchase through their online resources.

Photo 15: Working chute with crash gate. Tracy Bolls, Rangeland Management Specialist, North Dakota NRCS.

Photo 16: Bison working chutes. Tracy Bolls, Rangeland Management Specialist, North Dakota NRCS.

Watering Facility

CPS 614 – Watering Facility can be used to store or provide drinking water for bison or other livestock and wildlife. The watering facility should be designed to accommodate the number of animals that will be drinking at the same time and include elements to meet the specific needs of the primary users.

For bison, a consideration is to install drinkers that allow for increased body spacing to enable herds of animals to water more quickly and to reduce confrontation with dominant individuals. Consider specific design needs that include horn size, behavior, and ingress and egress to reduce competition and conflict approaching and leaving the drinker. Herds larger than 50 head will have multiple ingress/egress points.

Photo 17: Bison and watering facility. Tracy Boll, North Dakota NRCS.

Design troughs and tanks with the storage volume necessary to provide water between periods of replenishment (NRCS CPS 614, 2023).

Bison water requirements and intake are dependent on multiple factors, including DMI, physiologic status, age, weather, and management regime, among other things (Kirk Baer, 2024; CBA, 2017; Parker, 2017). General rules of thumb for bison with science-based estimates range from 10-15 gallons of water per day per animal.

Drinkers should be anchored down or braced to prevent overturning by wind and animals, or as required by the watering facility manufacturer. Drinkers designed for bison should be void of lips or edges that animals can hook with a horn and overturn (NBA, RD, 2024). Drinkers should be made with materials and constructed to withstand bison bull's strength and weight. Bison have flight-or-fight responses when threatened and drinkers create an area where animals may crowd. Sturdy construction will also increase safety for bison and reduce injuries if animals jump or get pushed into the facility. Drinkers made of durable material and sturdy construction will help meet the intended lifespan of the structure.

Install the watering trough or water storage tank on a firm, level foundation that will not settle differentially. Examples of suitable foundation materials are bedrock, concrete, compacted gravel, and stable, well-compacted soils. Where necessary, prepare the foundation by removal and disposal of materials that are not adequate to support the design load (NRCS 614, 2023). Consider the use of Conservation Practice Standard 561– Heavy Use Area Protection around the watering facility. For more details, refer to the CPS 561 section below.

Photo 18: Bison calves drinking on a pedestalled or base-scoured drinker. Karen Conley.

Drinker bases and aprons can prevent scouring or undercutting around the drinker due to heavy use. Apron widths should extend 4 feet out from the drinker or to your state's specific recommendations. Pedestalled drinkers increase drinker heights and may prohibit shorter animals from having access. Consider drinker depths of 24 inches or less to allow access and escape for smaller animals, such as calves.

Also, consider building drinker aprons with materials that may help encourage shorter loafing time, such as aprons made with coarse aggregate. Construction of watering facilities to shorten loaving time may encourage dominant individuals to drink and move off, enabling subordinate individuals more access to water and reduce wear to and around the facility.

Bison will also utilize rain-fed puddles and wallows for water sources. They will consume snow as a water source if the snow is edible. Trampled on, soiled, or icy snow is not a good source of water for bison (Gov of Saskatchewan). Producers need to be careful when grazing fields in winter with open water bodies as bison are not cautious about walking onto thin ice. There are reports of animals breaking through ice and drowning (Canadian, 2022).

Consult the NRCS State Conservation Engineer, State Resource Conservationist, or State Grazing Specialist in your state for more information on watering facility standards and specifications.

This technical note does not supersede state guidance, State Standards, State Specifications, or State Implementation Requirements (Designs) for Watering Facilities.

More information on CPS 614 – Watering Facility can be found in your state's Field Office Technical Guide or in the USDA National Standard Document.

Heavy Use Area Protection

CPS 561−Heavy Use Area Protection can be used to stabilize or protect intensively used areas including areas or aprons around livestock watering facilities. This practice can address purposes that reduce soil erosion, provide stable, noneroding surfaces for areas frequently used by animals and help protect and improve water quality (NRCS CPS 561, 2020).

Base the design load on the type and frequency of the animal traffic anticipated on the heavy use area. Evaluate the site foundation to ensure that the presumptive bearing capacity of the soil meets the intended design load and frequency of use for the anticipated climate conditions. Prepare the foundation by removal and disposal of materials that are not adequate to support the design loads. Use a base course of gravel, crushed stone, other suitable material, geotextile, or a combination of materials on all sites that need increased load-bearing strength, drainage, separation of material, and soil reinforcement (NRCS CPS 561, 2020).

Select a surface treatment that is stable and appropriate to the purpose of the heavy use area. When concrete is used for livestock, imprint or texture concrete to provide traction in wet or freezing conditions. Design the structure and slabs-on-ground in accordance with the NRCS National Engineering Manual (NEM) (Title 210), Part 536, “Structural Engineering”. When using aggregate, design surfaces for expected wear and intended use. In lieu of a site-specific design, install a minimum combined thickness for aggregate surfacing and base course of 6 inches for animals. Avoid the use of angular aggregates that might injure livestock. (NRCS CPS 561, 2020).

Use vegetative measures only on areas where traffic can be managed so the vegetative cover can be maintained. Select grass species or other plant materials that are wear resistant, have fast recovery from heavy use, and are suitable to the site. Establish the vegetation in accordance with the criteria in NRCS Conservation Practice Standard (CPS) Critical Area Planting (Code 342) or the appropriate State reference. For heavy use areas managed as vegetated lots, provide an adequate number of lots in the system to allow the vegetation to be sustained by moving the animals. Establish a rotation that ensures the vegetated lot will be used only when vegetation has had time to recover between animal activities. (NRCS CPS 561, 2020).

Include provisions in the design for surface and subsurface drainage as needed. To reduce the negative water quality impact of heavy use areas, consider locating them as far as possible from water bodies or water courses. Fill low areas that may contribute to subgrade instability or groundwater contamination. If there is the potential for ground water contamination from the heavy use area including animal wastes, select another site or provide an impervious surface to reduce infiltration of pollutants (NRCS CPS 561, 2020).

Consider the effects on improved animal health from the installation of heavy use area protection on muddy sites. Mud transmits bacterial and fungal diseases and provides a breeding ground for flies. Hoof suction makes it difficult for animals to move around in muddy areas. In addition, mud negates the insulation value of the hair coat, and the animals must use more energy to keep warm. As temperatures fall, animal bunching may occur, which can lead to erosion and water quality concerns (NRCS CPS 561, 2020).

Consult the NRCS State Engineer, State Resource Conservationist or State Grazing Specialist in your state for more information on Heavy Use Area Protection standards and specifications.

This technical note does not supersede state guidance, State Standards, State Specifications, or State Implementation Requirements (Designs) for Heavy Use Area Protection.

More information on CPS 561 – Heavy Use Area Protection can be found in your state's Field Office Technical Guide or in the USDA National Standard Document.

Feed Bunks

When feed bunks are used for bison, provide a minimum bunk space of 3 feet (or 1 meter) per animal (Canada, 2017). In feeder or stockyard pens, the confined feeding facilities should allow for a minimum of 250 square feet (or 23 square meters) per head of bison (Canada, 2017). It is recommended to minimize the use of head stalls on bale feeders and bunks to minimize the potential of horn damage.

Seeding Practices

CPS 512 – Pasture and Hay Planting and CPS 550 – Range Planting are practices available to establish desired vegetation. Both practices will have designs with seeding/planting rates, methods of planting, dates of planting, and species selection.

Pasture and Hay Planting

CPS 512 – Pasture and Hay Planting applies on all lands suitable for a one-time establishment of perennial species for forage production, such as pasture or hay land. When using CPS 512 on pasture or hay land for the additional criteria of improving or maintaining livestock nutrition and health, use forage species that will meet the desired level of nutrition (quantity and quality) for the kind and class of the livestock to be grazed or fed. Select species mixtures with similar palatability to avoid selective grazing, and select species with low or no toxic effects on grazing livestock. On pasture, bison will utilize tame forages, such as bluegrasses, brome grasses, timothy, and crested wheatgrass (Saskatchewan, 1999). However, bison do not perform well consuming bermudagrass with the primary concern occurring in unfertilized monoculture bermudagrass pastures (Martin and Brooke, 2023).

Alfalfa and clovers can be used in pasture mixes and used for stockpiled forages, although some producers have reported that bison prefer grass to alfalfa when grazing (Saskatchewan, 1999). Careful consideration should be used when planning alfalfa and coastal bermudagrass as forage as both species potentially will not provide adequate nutrition to bison. The Canadian Bison Association (2022) provides a pasture and grazing management publication that addresses bison and grazing alfalfa called Bison Pastures and Grazing Management.

More information on CPS 512 – Pasture and Hay Planting can be found in your state's Field Office Technical Guide or in the USDA National Standard Document.

Range Planting

CPS 550 – Range Planting applies to land where the principal goals and methods of vegetation management are or will be based on ecological processes and interactions. This is generally rangeland, and the practice will be applied where desirable vegetation is below the acceptable level for natural reseeding to occur or where the potential for enhancement of the vegetation by management of herbivory is unsatisfactory.

When using CPS 550 for the additional criteria to improve forages for livestock on rangeland, select species or combination of species that will meet the desired nutritional requirements for the kind and class of livestock that will utilize the forage and that will meet the desired season of use or grazing period. Species planted as mixtures should be of compatible palatability to avoid selective grazing.

Some considerations when contemplating range plantings for bison can be taken from a study conducted on seasonal bison diet patterns across 45 climate gradients in North America by Craine (2021). He found that C3 grass protein intake was highest in May and lowest in September, C4 grass protein intake peaked in September and was lowest in July, legume protein intake peaked in August and was lowest in May, and forb protein intake peaked in June and was lowest in August. Therefore, when implementing range planting within grazing units, it is important to consider the timing of use. Selecting species from appropriate functional groups for the seed mix can ensure that bison have access to the desired forage during their critical weight gain period.

Remember providing plentiful, good quality forage especially in the summer is important to successful bison ranching. It is important to have second growth or actively growing vegetation from July to October (Canadian, 2022). Bison gain weight in the summer and fall to prepare for their natural metabolic slowdown during the winter.

More information on CPS 550 – Range Planting can be found in your state's Field Office Technical Guide or in the USDA Conservation Practice Standard.

Photo 19: Bison. NRCS.

Diseases

Bison, like other animals, are susceptible to various pathogens, parasites, and nutritional deficiencies and toxicities (Martin and Brooke, 2023). Many producers work with veterinarians to develop vaccination and deworming programs for their herds. Being educated on the diseases and symptoms that can affect bison is important to facilitate decisions for individual animals and for the herd.

The NBA provides a Bison Diseases Field Guide available on their member's website or for purchase through their online resources.

The International Symposium on Bison Health presentations are available from the Canadian Bison website for a variety of health relative topics or on the member's link from the National Bison Association website.

Ecosystem Services

Bison are considered native megafauna to many grasslands in the United States (Martin et al., 2023). Currently, there is interest and research being conducted to understand the effects bison have in the role of plant community diversity and what the effect of reintroducing or “rewilding” these native megafaunas could have in restoration efforts. Bison are considered ecosystem engineers who have helped shape healthy and diverse ecological communities (NPS, 2016a). Bison behaviors, such as trailing, wallowing, horning and trampling, are important influences on plant and animal diversity (NPS, 2016d).

There are three categories of ruminants; 1) Grazers – that select mostly grasses and sedges, 2) Browsers – that select mostly forbs and shrubs or shrub parts, and 3) Mixed feeders – that have adapted to grazing grasses, forbs, and shrubs (Canadian, 2022). Bison and cattle fit into the Bulk Grazer or Grass Selector group; however, bison are seasonal mixed feeders that focus on grass during the peak growing season but select more forbs, legumes, and shrubs in the non-growing season, and like other domesticated livestock, provide seed dispersal through their hair coats and digestive tracts. As they move across the landscape, they inadvertently spread seeds, contributing to plant diversity and potentially ecosystem resilience. They can also affect the soil by providing soil aeration in some cases, compaction and ground disturbance in others. Their hoof prints can cause depressions that can contribute to microhabitats for various species.

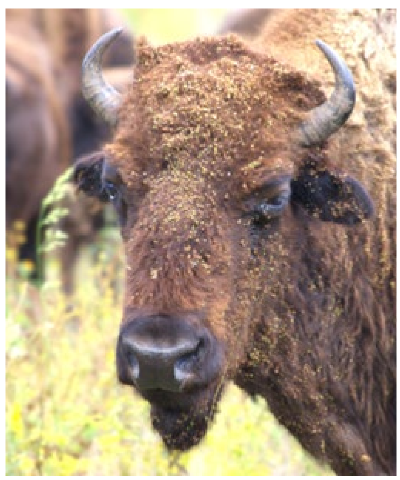


Photo 20: Seed stuck to bison face. Bradly Wehus-Tow.

In a study by Oklahoma State University, Rosas et al. (2008) found that bison hair samples collected from three groups (19 bulls, 45 cows, and 47 juvenile bison) each month for a year contained over 2,700 seeds from at least 76 different plant species. Several of these species did not have specialized features for adhesive dispersal. They also found that seed species composition found in the hair did differ between the groups. This was possibly due to differential habitat use.

They found that bison dung contained over 7,400 seeds from at least 70 different species. Twenty-seven of those species were different graminoids (grasses, sedges, and rushes) and accounted for 53% of the total number of seeds found (over 3,900). Their results were similar to other research that concluded bison are important dispersers of graminoids and forbs and may play an important role in the life history of many tall grass prairie species.

Bison grazing behavior and grazing patterns can influence the composition of plant communities. By selectively consuming certain types of vegetation, such as grasses and sedges, while leaving more of the forbs, bison help maintain a diverse mix of plant species. Ratajczak et al. (2022) found in a 29 yearlong study on the Konza Prairie Biological Station in Eastern Kansas, that bison can help increase plant community diversity with their diet selection by more than double that of domesticated livestock. They introduce the term “keystone herbivory,” which relates to native megagrazers that have evolved digestive systems and selective foraging traits that can reduce the abundance of palatable grasses that dominate in the absence of grazers. This can increase species richness in grasslands that, in turn, can benefit other animals and pollinators that rely on specific plants for food or shelter.

Photo 21: Bison with seed and vegetation. South Dakota NRCS.

Another impact bison and other livestock and wildlife have on ecosystems is in the deposition of dung and urine. Bison produce 10 to 12 quarts of dung and gallons of urine daily (NPS, 2016d). Both are important sources of nitrogen, phosphorus, calcium, sulfur, and magnesium for soil microbes, plants, and other animals (NPS, 2016d). Nutrient cycling through bison waste starts in the rumen, the first of the bison’s four stomach chambers. The process of rumination involves breaking down food and enlists a diverse microbial community to digest plant material. These microbes, along with undigested plant matter, are then excreted onto the soil through the bison’s feces and urine. Bison droppings are nutrient-rich additives to the soil and attract insects, such as dung beetles, to the area.

Bison can have an effect on woody species through uprooting seedlings and saplings, or horn rubbing on larger trees that damages bark and cambium layers. These activities can be positive or negative depending on the woody species, their role and value ecologically to the site, or the goals of the operation. In places where reducing woody species is desired, bison can open the canopy layer and increase sunlight to understory. Dead trees or snags can provide insect and pollinator habitat.

An example where bison caused tree mortality that was beneficial is with the endangered Karner blue butterfly in central Minnesota. Reintroducing bison has played a role in restoring the open oak savannah, increasing sunlight to important flowering plants that provide nectar and sites for the butterfly to lay its eggs (NPS, 2016d).

Photo 22: Karner blue butterfly. Justin Meissen, Scientist, Tallgrass Prairie Research Center at Northern Iowa.

Bison can also cause mortality on species, including aspen, cottonwoods, and lodgepole pines among others, that may be beneficial to the ecosystem or the operation (Beschta et al., 2020). During periods when grasses are limited, bison can adjust their diets to as high as 20-40% on shrubs, such as willows (Canadian, 2022). Monitoring bison effects on desirable species to the operation is important.

Another distinctive characteristic of bison is their wallowing behavior (Martin and Brooke, 2023). Wallowing or “dust baths” help bison deter biting insects by creating a dirt layer on their bodies that potentially help regulate body temperature. Wallowing can also help them shed winter fur resulting in the dispersal of seed trapped in their fur.

Wallows are bowl-like depressions that, when rain filled, can act as small ponds or reservoirs and can serve as important ecological features. The disturbed-compacted soil can provide habitat for pioneer plants (US NPS, 2016b) and plants that are more hydrophilic than surrounding areas, thereby creating greater plant diversity on the landscape. These wallows can also become breeding grounds for amphibians, other small organisms, and invertebrates (US NPS, 2016b). In fact, the National Park Service stated that before European settlement, there were an estimated five or more bison wallows per acre over an historic extent of 500,000 square miles (US NPS, 2016b). Some old relict wallows can still be seen aerially due to the change in vegetation within and around the wallow.

Wallows should be left on the landscape and not filled in. If a wallow gets filled, the bison will simply open a new wallow in a different location. Providing deferment to grazing units will help disturbed areas, such as wallows, regrow vegetation and help them remain stable from erosion. If remediation of a wallow is desired, seeding practices, such as CPS 512, CPS 550, or CPS 342 – Critical Area Planting, may be used to help restore vegetative cover. See the Seeding Practices section on page 29 for more information.

Wallows can be counted as temporary sacrificial areas when determining stocking rates (Martin and Brooke, 2023).

Cultural Significance

For centuries, people and bison (American buffalo) have shared a deep connection, whether as a vital resource for livelihood or as a powerful symbol in U.S. history. As a result, in 2016 the North American Bison was declared the national mammal of the United States, joining the ranks of the bald eagle as a national symbol. This achievement was made possible through the dedicated efforts of the Wildlife Conservation Society, the Intertribal Buffalo Council, the NBA, other organizations, and over 60 members of the Vote Bison Coalition. Their outreach to Congress and the White House culminated in the signing of The Legacy Act on May 9, 2016, officially recognizing the bison as our national mammal. This historic event marks a remarkable comeback story, rich in history, culture, and conservation (US NPS, 2016).

Illustration 11: U.S. National Mammal Seal. National Park Service.

Beyond their ecological impact and potential to revitalize local economies, bison hold profound cultural significance for many Native American tribes. For thousands of years, these majestic animals have been central to their lives, providing essential resources, such as food, clothing, shelter, jewelry, and tools (US NPS, 2015). Bison also play a vital role in celebrations and ceremonies, symbolizing life, abundance, and survival. With over 150 documented uses, bison are truly a cornerstone of Native American heritage and resilience (US NPS, 2015).

John Fire Lame Deer exemplified this importance in his words, "*The buffalo gave us everything we needed. Without it we were nothing. Our tipis were made of his skin. His hide was our bed, our blanket, our winter coat. It was our drum, throbbing through the night, alive, holy. Out of his skin we made our water bags. His flesh strengthened us, became flesh of our flesh. Not the smallest part of it was wasted. His stomach, a red-hot stone dropped in to it, became our soup kettle. His horns were our spoons, the bones our knives, our women's awls and needles. Out of his sinews we made our bowstrings and thread. His ribs were fashioned into sleds for our children, his hoofs became rattles. His mighty skull, with the pipe leaning against it, was our sacred altar" (*Bison or Buffalo & Native Americans).

Bison are integral to food security for many Indigenous societies. Traditional harvests of buffalo were through the buffalo jump or buffalo impoundments (US NPS, 2016). Prayers before and after the hunt were part of the bison calling ceremonies that were an integral part of keeping a respectful relationship with the buffalo's spirit (SDSU, 2024). Buffalo are still significant in Native American traditions and ceremonies and offer a healthy protein source alternative to commercial beef. More than 60 tribes across the United States have made significant efforts to restore food security—ensuring food is available and accessible—and food sovereignty, which is the ability to access healthy and culturally appropriate food. For many tribes, achieving these goals is closely linked to the restoration of bison herds on their traditional lands (Shamon et al., 2022).

Sacred to Native Americans, each tribe has its own special relationship with bison (LaPier, 2023; Ettsitty, 2024). Buffalo are generally not thought of as livestock to many tribes but as a relative or wildlife (Griffin, 2024) and are considered a sacred animal and represent their spirit (NFWF, 2024). Environmental historian Dan Flores states that Indigenous peoples and bison "co-evolved," meaning they influenced each other's actions and behaviors (Flores, 2022; LaPier, 2023). Gerard Baker, from the Mandan Hidatsa tribe, stated in Ken Burns' *The American Buffalo* PBS special that, "When you look at a buffalo, you don't just see a shaggy beast, you see life, existence, and hope, they are our relatives and a part of us" (Burns, 2023). Restoring bison to tribal lands is a way to restore cultural practices and strengthen community identity (Smithsonian, 2022).

Photo 23: Tatanka Skah Wanagi (White Buffalo Spirit) Pinkman, Robin Kamay, TX.

Bison promote cultural connection by reviving traditional practices and ceremonies that were disrupted by historical events. They are the topic of education to teach younger generations about their heritage, sense of identity, and continuity. Through education and traditional ecological knowledge, the wisdom, practices, and beliefs developed by Indigenous peoples through their long-term interaction with the environment are passed down from generation to generation.

Bison are integral to traditional ecological knowledge as a keystone species whose presence and behaviors have a profound impact on the ecosystem and creating habitat for other species (Smithsonian, 2022). Traditional ecological knowledge helps tribes manage sustainable grazing and maintain soil health. Bison are important for spiritual ceremonies and healing and promote community cohesion. Their survival and comeback are a testament and symbol of resilience and enduring strength of Indigenous peoples.

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