# American Prairie Reserve Bison Grazing Proposal - Scientific Basis and References

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**Table of Contents**


| | |
|---|---|
| Comparison of Rotational and Year Long Grazing | 3 |
| Comparison of Bison and Cattle Grazing Patterns | 6 |
| Bison Grazing Effects on Wildlife Habitat | 14 |
| Fence Effects on Wildlife | 18 |
| Need to Conserve Bison | 18 |
| APR BIson Population Estimates and Stocking Plans | 22 |
| Need to Conserve Fully Functioning Grassland Ecosystems | 25 |
| Bison and Cattle Interactions | 31 |
| Bison and Human Interactions | 33 |
| Bureau of Land Management and Montana Department of Natural Resources | 36 |
| References | 39 |
| Appendix 1 - AUMs For Each APR Management Unit Using NRCS Method | 63 |

***Comparison of Rotational and Year Long Grazing***

A major change involved in the goal to restore natural herbivory patterns is to convert from rotational to year-round continuous grazing when bison replace cattle on the land. Year-round continuous grazing by multiple herbivores, including bison, characterized the region since the retreat of the last ice sheet some 12,000 years ago until the mid-1900s. Rotational grazing was supported by NRCS and implemented by BLM and many ranchers across the Great Plains in the 1970s. With rotational grazing came the extensive construction of interior fencing with negative consequences for many wildlife species; the removal of interior fencing in the transition back to year-round continuous grazing offers multiple benefits to wildlife and other environmental services.

NRCS, as part of their "Conservation Effects Assessment Project," published a comprehensive evaluation based on peer-reviewed literature titled *Conservation Benefits of Rangeland Practices: Assessment, Recommendations, and Knowledge Gaps* (Briske 2011). Its purpose was to provide evidence-based information to guide the development and assessment of NRCS-recommended management practices and conservation programs on the nation's rangelands. Three chapters in this review are relevant to rotational and continuous grazing questions. These reviews were based on grazing practices for common domestic livestock, primarily cattle, not bison.

The chapter by Briske et al. (2011) assessed grazing systems, including rotational and continuous grazing. The authors concluded that "The vast majority of experimental results indicate that there is no clear advantage of any one grazing system over another in terms of ecological benefits" (p. 52). They noted that this agrees with earlier reviews (Holechek et al. 1999, 2006) and reflects findings in an earlier report by Briske et al. (2008).

At a more detailed level, in comparing continuous with rotational grazing experiments at similar stocking rates, their NRCS review found that:

- Of 25 experiments, 86% indicated no difference in species composition;
- Of 19 experiments, 89% found no differences for plant productivity/standing crop;
- Of 28 experiments, 57% reported no difference for animal production per head and 36% found greater per head production for continuous grazing;
- Of 28 experiments, 57% reported no difference in animal production per unit of land area and 36% reported more production for continuous grazing.

Two studies reviewed by Briske et al. (2011) found no difference in livestock preference for site selectivity between rotational and continuous grazing. Forage availability, rather than stocking density or grazing system, appeared to be the primary mechanism affecting animal selectivity (Kirby et al. 1986, Heitschmidt et al. 1989).

Of four studies that Briske et al. (2011) found that directly compared forage quality between the two systems, forage quality was comparable in two cases and one each favored continuous and rotational grazing.

The above studies, according to Briske et al. (2011, p. 32), “indicate that rotational grazing does not promote primary or secondary production compared to continuous grazing within rangeland systems. These interpretations are consistent with those of previous reviews over the past 50 years (Heady 1961, Van Poollen and Lacey 1979, Holechek et al. 2001), and they clearly support the long-standing conclusion that stocking rate and weather variation account for the majority of variability associated with plant and animal production on rangelands.” Similarly, based on results of a change of use from cattle to bison and from rotational to year-round grazing on APR’s Box Elder Allotment, BLM (2015) concluded that on APR’s Flat Creek Allotment the same change of use is not expected to result a change in grassland species. BLM noted that this conclusion is in agreement from observations of a number of long-term grazing exclosures on BLM lands scattered throughout Phillips County.

A review by Briske et al. (2011) of the effects of the two grazing systems on water and soil resources found that, at moderate stocking rates, rotational grazing systems lead to similar or improved soil hydrologic function. Again, however, stocking rate overrides the grazing system in terms of effects on soil hydrologic function. They note that under moderate stocking, which is proposed for APR allotments, both continuous and rotational grazing may maintain a consistently higher level of hydrologic function compared to periodic heavy stocking followed by prolonged deferment. Concerning soil erosion, Briske et al. found no strong evidence that one grazing system is better than the other.

Briske et al. (2011) also reviewed effects of grazing practices on wildlife, and a separate NRCS review by Krausman et al. (2011) focused specifically on the effects of grazing practices on wildlife. Both reviews concluded that the small number of studies comparing effects on wildlife precluded making general conclusions. Of the studies Briske et al. reviewed, 17 showed no difference in wildlife responses to the two grazing system, 8 indicated rotational grazing was better and 8 indicated continuous was better. None of the studies reviewed provides conclusive information for comparing wildlife responses to rotational and continuous grazing in the mixed-grass/shrub-steppe habitats of eastern Montana.

Although controversy remains regarding the pros and cons of continuous grazing compared to various types of rotational grazing (Budd and Thorpe 2009, Teague et al. 2013), we note that almost all research and management are conducted within the framework of (1) cattle as the primary grazing animal and (2) a goal of ensuring profitability for the ranching operation. In many cases, especially on public lands, the goal also includes managing for biodiversity and other ecosystem services (Havstad et al. 2007).

APR, in contrast, is managing bison as the primary grazer and APR’s primary goal is the provision of biodiversity and other ecosystem services for public benefit. As such, APR’s grazing plan for bison is similar to many other areas that are managed for biodiversity and public benefit

and where there is year-round, continuous grazing by bison. These include national parks (e.g., Yellowstone N.P., Theodore Roosevelt N.P. in North Dakota, Badlands N.P. and Wind Cave N.P. in South Dakota), national wildlife refuges (e.g., National Bison Range in Montana, Fort Niobrara NWR in Nebraska, Wichita Mountains NWR in Oklahoma, Neal Smith NWR in Iowa), state parks and reserves (e.g., Custer State Park in South Dakota, House Rock Wildlife Area in Arizona, Henry Mountains and Antelope Island in Utah), and nonprofit reserves (e.g., The Nature Conservancy's Tallgrass Prairie Reserve in Oklahoma and Zapata Ranch in Colorado).

Bison have inhabited and continuously grazed the plains of eastern Montana since the retreat of the last continental ice sheet 12,000 years ago. About 150 years ago they were replaced by domestic livestock and became ecologically extinct because the few herds remaining were too small, confined and isolated to exert the ecological roles they once had in the Great Plains (Freese et al. 2007). Bison are a foundation species—species that have a disproportionate and often stabilizing effect on the diversity and structure of ecosystems (Dayton 1972, Ellison et al. 2005). Through grazing and other actions, bison have played a central role in the functioning of grassland ecosystems (Day and Detling 1990, Knopf and Samson 1997) as outlined for BLM Rangeland Health Standard #1, and, as described above and called for in BLM Standard #5, in supporting the diversity of grassland plants, birds, mammals and other wildlife (Coppock et al. 1983, Knopf 1996, Gogan et al. 2010, Gross et al. 2010).

Although the above NRCS review found little evidence that rotational grazing is needed to conserve wildlife and environmental services, one can probably create habitat heterogeneity or particular habitat types to meet particular biodiversity conservation goals through careful, evidence-based management of rotational grazing by cattle (Krausman et al. 2009). With good rotational management, one can likely mimic the natural conditions under which bison and other species and ecological processes created a shifting mosaic of habitat heterogeneity at larger landscape scales in the plains of eastern Montana. As Bud and Thorpe (2009, p. 13) observed, "Much of the attraction to rotational grazing systems comes from historic observations and perceptions of herbivore behavior in extensive unfragmented landscapes, where constant motion and different utilization patterns created and maintained highly variable, biologically rich ecosystems."

This observation suggests that the conversion from cattle grazing to bison grazing, if done on sufficiently large landscapes, removes the need to use rotational grazing to mimic the natural grazing conditions that existed in the plains of eastern Montana before Euro-American colonization. APR's goal is to return to these natural conditions by enabling bison to graze across large landscapes. Compared to cattle, bison are particularly well adapted to such conditions. As noted below, individual bison herds cover much more ground and have much larger grazing patches than cattle (Plumb and Dodd 1993, Kohl et al. 2013).

The above observations argue for not managing bison like cattle and even less so for managing bison with cross-fencing and rotational management units. Researchers and managers alike have reached this conclusion. Kohl et al. (2013) conclude that although they did not quantify the rangeland unit size that would permit approximations of historical use, their results indicate that

allowing bison to graze across large landscapes contributes to vegetation heterogeneity. Steuter and Hidinger (1999) comment that based on evolutionary history and domestication traits, cattle may be more appropriate in intensely managed agricultural systems, but “bison may be more appropriate in extensively managed, larger grasslands.” Fuhlendorf and Engle (2001) suggest that if bison is the primary grazer and increased biological diversity facilitated by vegetation heterogeneity at the landscape scale is an objective, compared to cattle, much larger pasture units may be required to facilitate bison movement, behavior, and resource use that more closely approximates historical bison populations.

***Comparison of Bison and Cattle Effects on Grasslands***

Ranchers and resource management agencies in the APR region have widely followed the common “take-half-leave-half” rule of thumb in rangeland management whereby livestock are managed to graze half of the standing forage down to a uniform height across the land. This goal is generally met by some form of rotational grazing, which nearly always involves the installation of cross fencing and of watering facilities to help uniformly distribute grazing across the landscape (Holechek et al. 2011).

The goal of natural herbivory merits extensive review here because the bison’s central role in restoring natural herbivory patterns involves fundamental and often controversial changes in management practices.

Cattle and bison are ruminants of the family Bovidae. New World cattle evolved and were domesticated, relative to bison, in warmer and more forested regions of southern Europe and tropical/subtropical regions of the Middle East, Africa and India (McTavish et al. 2013), whereas American bison and their ancestors evolved under colder temperate and subarctic conditions as their dispersal and evolution in the central grasslands of North America tracked the expansion and retreat of glacial ice sheets beginning 75,000-130,000 years ago. Since then, however, bison adapted as a habitat generalist to diverse ecological conditions by expanding their range to both humid and arid sub-tropical conditions of current-day southern U.S. and northern Mexico (Potter et al. 2010).

Cattle and bison have a large rumen compartment in relation to both body size and nutrient requirements (Demment and Van Soest 1985). Both are classified as “bulk/roughage grazers” in that they graze comparatively indiscriminately on herbaceous vegetation, in contrast to “concentrate selectors,” such as deer and elk, which feed more selectively on desired plants and plant parts (Hofmann and Stewart 1972). NRCS estimates average forage intake by cattle and bison to be the same, both with animal unit equivalents of 1, and thus considers them identical for AUM calculations (NRCS 2003).

Both cattle and bison consume primarily grasses and sedges in short-grass, mixed-grass and shrub-steppe ecosystems in North America. Bison, however, usually include a greater proportion of grass and sedge in their diet—more than 90%—than cattle, whose diet often consists of more than 15% forbs and shrubs (Peden et al. 1974, Van Vuren 1984, Van Vuren

and Bray 1983, Plumb and Dodd 1993, Hartnett et al. 1997, Gogan et al. 2010). Bison appear to show greater ability to digest and absorb nitrogen from low protein, high fiber forage than cattle, which may be related to significantly longer retention times of digesta in bison than cattle. Accordingly, bison have been reported to select rougher, less digestible forage (Peden et al. 1974, Schaefer et al. 1978).

The different evolutionary histories of bison and cattle and their ability to adapt to the mixed-grassland and shrub-steppe ecosystems of eastern Montana are reflected in their different bioenergetic requirements and responses to cold. To retain body heat bison possess a layer of subcutaneous fat and much denser hair coat than cattle (Peters and Slen 1964). Although responses may vary substantially among cattle breeds, bison and cattle display distinctly different metabolic responses to severe cold, with bison reducing their metabolic rate while cattle increase theirs as the temperature drops. For example, a temperature decrease from 0ºC to -30ºC (32ºF - -22ºF) resulted in an average increase of 33% in the metabolic rate of Hereford calves whereas bison calves showed a 19% decrease, and even at -30ºC (-22ºF ) the bison showed no sign of the decline being reversed. Bison calves are as cold tolerant at 6 months as Herefords calves are at 13-17 months (Christopherson et al. 1978, 1979). This low-temperature tolerance by bison may be particularly adaptive in the APR region where for 3 months of the year the average high never exceeds 0ºC (32ºF), for 6 months the average low is below 0ºC (32ºF), and for 3 months the average low is below -14ºC (6ºF) (data for Malta, Western Regional Climate Center 2017).

NRCS places the thermal-neutral zone for cattle at 5ºC – 20ºC (41-68ºF) (NRCS 2003). The average high for the town of Malta exceeds this range for 5 months of the year and the average low falls below it during 7 months of the year. Kohl et al. (2013) found little difference in time spent per visit at water between cattle and bison at 20ºC (68ºF), but as the temperature rose from 20ºC to 35ºC (95ºF) cattle spent increasingly more time at water than bison.

Projected increased temperatures in the Great Plains due to climate change may affect both cattle and bison through the direct effects of heat stress on animal behavior and health and through reduced forage production and quality (Craine 2013, Hatfield et al. 2014, Craine et al. 2015). We found no studies that compare how cattle and bison respond behaviorally to heat stress with respect to foraging patterns.

Adaptation to cold environments is also displayed by the bison's ability, in contrast to cattle, to forage in deep snow (Meagher, 1973, Carbyn et al. 1993). Because of these differences, bison are able to occupy and forage over the rangeland throughout winter whereas cattle are generally concentrated and provided supplemental forage during winter; this also results in lower input costs for bison than cattle.

Bison and cattle display similarities as well as important differences in foraging behavior, movement and other activities. Compared to cattle, commonly reported differences are that bison tend to use more open, upland habitats and avoid forests and riparian areas, spend less

time grazing during the growing season, move greater distances each day and forage over larger areas, and spend less time at and forage at far greater distances from water (Peden et al. 1974, Plumb and Dodd 1993, van Vuren 2001, Allred et al. 2011, Kohl et al. 2013).

In mixed-grass prairie systems of the Dakotas and Nebraska, bison exhibited a stronger preference compared to cattle for perennial grasses and they were strongly attracted to open landscapes during the growing season. Cattle included more forbs in their diet, and they use wooded areas and riparian zones more intensively. Despite greater grass consumption by bison than cattle, at similar annual stocking rates the amount of grass remaining at the start of the dormant season was higher under year-round bison grazing compared to growing-season cattle grazing (Steuter and Hidinger 1999). Plumb and Dodd (1993), in the mixed-grass prairie of Wind Cave National Park, South Dakota, also reported bison consume proportionally more grass than cattle, exhibited greater daily movements over larger areas, spent less time at water and foraged at greater distances from water.

In the mixed-grass/shrub-steppe region of two study sites in northeast Montana (American Prairie Reserve) and southern Saskatchewan (Grassland National Park), Kohl et al. (2013) reported that cattle spent a higher proportion of time grazing (45–49%) than bison (26–28%), grazed sites of higher plant biomass, spent more time at water, and had a foraging patch size 20 or more times smaller (Figure 1). The foraging patch size of cattle was 119 - 1,519 acres (48 – 615 ha). Range management guidelines assume distances of 1.0 - 2.0 miles (1.6 – 3.2 km) from water to be of moderate forage availability and further distances as much less accessible to cattle (Holechek et al. 2011, Lyons and Machen n.d.). The forage patches of 119 - 1,519 acres found by Kohl et al., if centered on single water sources, would indicate cattle were seldom moving more than a mile from water.

In contrast, the 8,781-acre (3,555-ha) pasture unit on the APR study site revealed no small-scale patch use by bison, suggesting that a single bison foraging patch encompasses a larger area. This was confirmed by the larger pasture unit in the Grassland National Park study site where the bison summer foraging patch was 28,874 acres (11,690 ha) (Kohl et al. 2013).

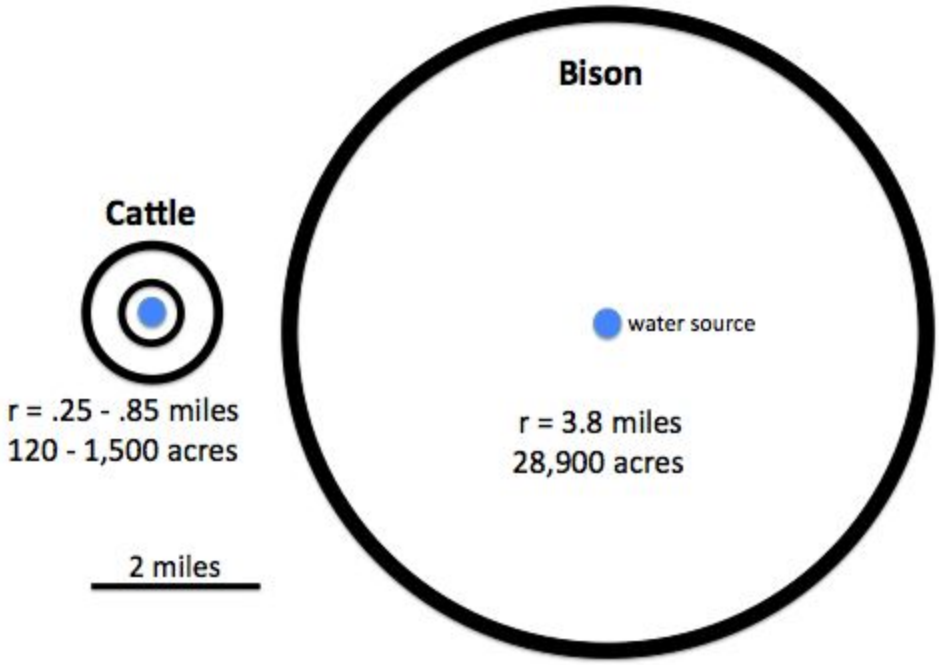



***Figure 1. Schematic illustrating the difference in foraging patch size between cattle (2 black circles indicate range) and bison, based on Kohl et al. (2013). The radius (r) from the water source to the circle(s) reflects the greater tendency for bison to travel much further than cattle from water sources while foraging.***

Kohl et al. (2013) comment that increased grazing and decreased movements by cattle found in their study, when combined with livestock stocking levels that they suggest are twice that of historic bison, are compatible with the hypothesis that current range practices are resulting in homogeneous grazing at a landscape scale and thus contributing to the decline of prairie-obligate species (Knopf 1996; Fuhlendorf et al. 2006).

If increased biological diversity facilitated by vegetation heterogeneity at the landscape scale is an objective (Fuhlendorf et al. 2006) and domestic livestock are used as the dominant grazer, Fuhlendorf and Engle (2001) suggest that alteration of grazing intensity across many pasture units may be effective. If increased vegetation heterogeneity through bison grazing is an objective, they conclude, similar to Kohl et al. (2013), that larger pasture units may facilitate bison movement, behavior, and resource use that more closely approximate historical bison populations.

McMillan et al. (2017) evaluated three treatments on APR: where livestock continuously grazed, livestock were removed for 10 years, and bison have been introduced and resident for 10 years.

They found higher species richness and compositional heterogeneity (β-diversity) in the bison treatment than either the livestock retention or livestock removal treatments. Bison restoration, however, resulted in lower forb abundance and comparable bare ground and plant height heterogeneity compared to sites where livestock were retained.

A comparative study on The Nature Conservancy Tallgrass Prairie Reserve in Oklahoma (Fuhlendorf et al. 2010) found that both cattle and bison strongly preferred recently burned areas and avoided steeper slopes. Cattle selected areas that were closer to water and preferred areas with woody vegetation, while bison were not limited by distance to water and avoided woody vegetation. GPS information did not allow determination if woody vegetation was used by cattle for resting or grazing. Preferences by both species for burned areas have been reported in other studies (Coppedge et al. 1998, Fuhlendorf and Engle 2001).

At another tallgrass study site, the Konza Prairie Biological Station in the Kansas, a 10-year study compared vegetation changes in prairie that was burned and grazed season-long at a moderate stocking rate by either bison or cattle. Trends in species cover and diversity indices in the bison and cattle pastures were compared with ungrazed prairie that also was burned annually. Grazing by either herbivore increased the canopy cover of annual forbs, perennial forbs, and cool-season graminoids, but both annual and perennial forb cover increased at a greater rate in bison pastures than in cattle pastures. Species richness at both small (10 $m^2$) and large (200 $m^2$) spatial scales increased at a greater rate in bison pastures than in cattle pastures, but richness did not change through time in ungrazed prairie. The number of annual forb species was significantly greater in bison pastures than in cattle pastures. Residual graminoid biomass at the end of the grazing season was lower in bison pastures than in cattle pastures, whereas forb residuum increased over time at a greater rate in bison pastures than in cattle pastures. Despite these differences, the plant communities in bison and cattle pastures were 85% similar after 10 years of grazing. The authors conclude that most measurable differences between bison-grazed and cattle-grazed pastures in tallgrass prairie are minor, and differences in how the herbivores are typically managed may play a larger role in their impact on prairie vegetation than differences between the species (Towne et al. 2005).

Observations on Konza Prairie suggest that bison alter plant community composition at the patch scale by selecting species-poor, grass-dominated sites and converting them to sites of higher diversity (Knapp et al. 1999). At the watershed and landscape scales, the long-term consequences of bison activities include a reduction in cover, dominance, and productivity of grasses; the competitive release of many subdominant species, resulting in an increase in the abundance of forbs; an overall increase in plant species richness and diversity; and increased spatial heterogeneity (Knapp et al. 1999). Bison grazing of short- and mixed-grass prairie has been shown to increase rates of nutrient cycling (Day and Detling 1990), modify plant species composition (Coppock and Detling 1986) and increase the nutritive value of grasses (Coppock et al. 1983a, 1983b, Krueger 1986).

Based on observations of a change of use from cattle to bison in place since 2008 on APR's Box Elder Allotment, BLM (2015b) reported in their assessment of the Flat Creek Allotment Change of Use that no change in grassland species is expected to occur in the transition from cattle to bison and from seasonal rotational grazing to year-round continuous grazing. BLM noted that this conclusion is in agreement from observations of a number of long-term grazing exclosures on BLM lands scattered throughout Phillips County.

In the arid, semi-arid and alpine habitats of the Henry Mountains of south-central Utah, bison used steeper slopes and higher elevation than cattle and spent less time close to water (van Vuren 2001, Ranglack and du Toit 2015). In northern Colorado, Peden et.al. (1974) found that bison spent less time near water and only watered once a day. Pinchak et al. (1991) reported that 77% of the observations of cattle grazing foothill ranges in Wyoming were within 0.23 miles of water. Other studies have shown that cattle are attracted to the shade of woodlands and riparian zones, both during the heat of the summer and for protection from wind and cold during winter (Smoliak and Peters 1955, Sneft et al. 1985, Van Vuren 1984, 2001).

In upland systems, the above comparative studies demonstrate no major differences between cattle and bison in terms of effects on rangeland health and biodiversity, particularly in semi-arid grasslands. Though cattle and bison differ significantly with respect to foraging patch size and minor differences exist in proportion of grasses and forbs consumed, both species are primarily grass grazers and habitat generalists. As shown in one tallgrass prairie site, long-term bison grazing may favor an increase, relative to cattle grazing, in forb diversity and abundance. This would benefit forb foragers such as greater sage-grouse (Dahlgren et al. 2015) and pronghorn (Bayless 1967, Wentland 1968). As Biodini et al. (1998) note, however, their study of mixed-grass prairie in North Dakota confirms previous observations that, in northern mixed-grass prairie, climatic variations, particularly droughts, control major trends in plant species composition and net primary productivity, with grazing and grazing systems playing a secondary role.

We agree with a broad consensus among rangeland scientists and managers that, under current NRCS and BLM rangeland management conditions and measures of success, the most important variables affecting biodiversity and overall rangeland health are stocking rate, weather, and adaptive management. Excessive stocking and bad management decisions, regardless of the grazer, will lead to ecological degradation. Light to moderate stocking levels and good management generally result in good outcomes (Heitschmidt and Taylor 1991, Biondini et al. 1998, Steuter and Hidinger 1999, Holechek et al. 2011, Towne et al. 2005, Allred et al. 2011, Briske et al. 2011, Krausman et al. 2011).

By following BLM and NRCS rangeland management guidelines and maintaining moderate stocking levels, rangeland science therefore suggests that BLM rangeland health and biodiversity will be at least maintained in the transition from cattle to bison. Moreover, APR's work to restore native grassland on cropland on base properties offers the opportunity to

improve conditions of BLM allotments by increasing the amount of intact rangelands with which they are associated.

Grassland plants and animals of the mixed-grass prairie and sagebrush steppe of eastern Montana co-evolved with bison for thousands of years. Domestic cattle replaced bison on these landscapes approximately 150 years ago—just 1% of the 12,000-year post-glacial period during which bison were the region's dominant grazer. The transition back to bison offers an evolutionarily tested means for restoring habitats that, as set forth in the BLM HiLine Rangeland Health Standard #5, "maintain healthy, productive and diverse populations of native plant and animals species."

Large variations in flow of intermittent and perennial streams are vital to biogeochemical and ecological processes that create diverse habitats and support unique assemblages of prairie fish and other organisms (Smith et al. 2002, Dodds et al. 2004). Fluctuation in stream flows and availability of water also influence grazing patterns; scarce water sources can be expected to create variable grazing conditions across the landscape as animals must travel further between water and grazing sites (Allred et al. 2011). This factor is important in the transition from grazing by cattle, which preferentially graze close to water sources, to grazing by bison, which readily graze at much greater distances from water (Kohl et al. 2013).

The intensive use of riparian areas and streams by cattle has been extensively reviewed in the literature. An NRCS-sponsored comprehensive review—the Conservation Effects Assessment Project—demonstrated the high level of cattle use of streams and riparian areas and the resulting ecological degradation of these habitats under most commonly used grazing regimes in the West. Degradation or loss of hydrologic function, water quality, riparian and stream habitat, and biodiversity are common (Briske et al. 2011, George et al. 2011), similar to the findings of earlier reviews (Kauffman and Krueger 1984, Belsky et al. 1999).

Stream surveys in 2008 and 2009 that included sites in the APR region found 77% of warm-water streams and rivers in the Montana plains had "high levels of riparian disturbance," greatly exceeding natural rates of disturbance. Only 6% had low levels of disturbance. Similarly, 77% of riparian vegetation cover was classified as "poor," while 47% of in-stream fish habitat was rated as "poor" and 35% as "good." Measures of streambed sediment found 50% "good," 22% "fair" and 24% "poor" (Teply 2013). As another biological indicator of these poor stream and wetland conditions, ten species of fish and two species of amphibians found in the region are Montana Species of Concern (Montana Natural Heritage 2016). In addition, three species of amphibians and five species of fish are BLM Sensitive Species, and one bird that depends on proper wetland conditions (piping plover) and one fish species (pallid sturgeon) are a BLM Special Status Species.

APR's conversion from cattle to bison will help address concerns about the effect that the change from rotational to year-round continuous grazing may have on streams and riparian areas. These concerns emerge from the well-known preference of cattle to use riparian areas

and for grazing close to water sources. Regarding riparian areas, George et al. (2011, p. 216) concluded from their NRCS review that “continuous grazing often results in heavy grazing use of the riparian area because livestock are attracted to riparian areas from adjacent uplands.” For this reason, they reported that the case histories they reviewed suggest that continuous grazing is not compatible with riparian areas. While they note that rest rotation or deferment grazing tends to improve riparian habitats, they also caution (p. 216) that “Improperly applied rotational grazing systems can also result in heavy grazing and damage to riparian areas.” In contrast, bison tend to avoid wooded riparian areas, come to water less frequently than cattle, and spend much less time grazing near water sources. Thus when bison are allowed to graze at moderate stocking levels over large landscapes with a diversity of habitats, they are much less likely to cause degradation of streams and riparian habitats. Where restricted or total cessation of use by bison of a stream or riparian habitat is required for restoration purposes, temporary fencing and/or temporary provision of other water sources may be employed.

Many streams and riparian areas are degraded on properties that APR has acquired. Because bison are less dependent on permanent water sources and come to water sources less frequently and for shorter periods than cattle (Kohl et al. 2013), the transition to bison grazing is expected to improve water quality in streams and reservoirs and to aid in the restoration of streams and riparian areas for wildlife.

Bison engage in horning by rubbing an object, typically a shrub or small tree, with its head, horns, neck and shoulders (Coppedge and Shaw 1997). Horning damage to trees along grassland borders slows invasion of trees into shrub and grassland communities and may enable grassland to penetrate the forest margin (Gogan et al. 2010). Bison horning, in combination with fire, drought and other factors, may have limited the historic distribution of woody vegetation in the Great Plains (Campbell et al. 1994, Coppedge and Shaw 1997, Edwards 1978). Bison, facilitated by their dense hair, may be important dispersers of both graminoid and forb seeds. Hair samples from 111 bison in a tallgrass prairie yielded 2,768 seeds representing at least 76 graminoid and forb species. Dung sampling yielded at least 70 species (Rosas et al. 2008).

A large ungulate carcass, particularly those of bison and elk, creates a major disturbance marked by a large nutrient pulse, increased soil microbial activity and nematode abundance, and a succession of new plant growth that is distinct from surrounding prairie vegetation. Plant growth in a nutrient-rich ring around the disturbance may create positive nutrient feedback by attracting grazers whose urine and dung expand the nutrient-rich patch (Towne 2000, Truett et al. 2001, Wilmers et al. 2003, Carter et al. 2007, Bump et al. 2009). Decaying ungulate carcasses may thereby contribute to habitat heterogeneity and to species richness at all taxonomic levels--from plants to insects to soil microbes. Historically, this effect may have been magnified by episodic bison die-offs that produced a slew of carcasses (Knapp et al. 1999, Freese et al. 2014).

APR bison that have died of natural causes have not been moved and have been scavenged by various species and allowed to decompose and the nutrients recycled on the prairie.

***Bison Effects on Wildlife Habitat***

The BLM Sensitive Species designation is used for species requiring special management consideration to promote their conservation and reduce the likelihood and need for future listing under the Endangered Species Act" (August 18, 2014 Instruction Memorandum No. MT-2014-067). The highly endangered black-footed ferret is a BLM Special Status Species. Among BLM Sensitive Species in northeast Montana are the black-tailed prairie dog and swift fox, roughly two dozen bird species, five reptile species, three amphibian species, five fish species, and numerous species of plants.

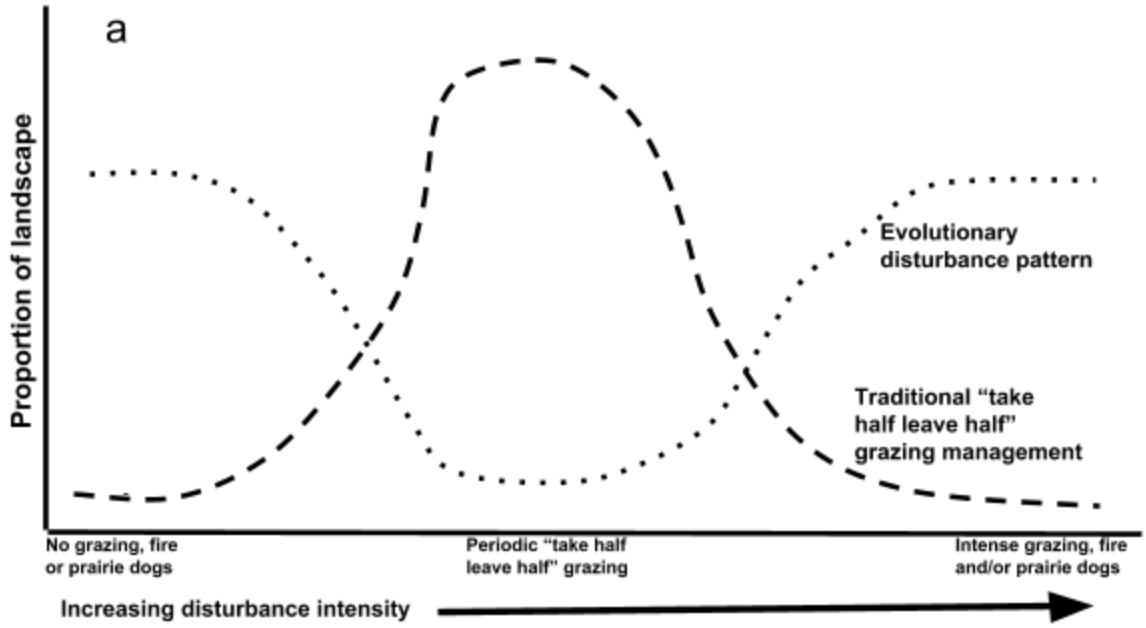
Restoring and maintaining landscapes with a high proportion of grasslands is important for conserving sensitive grassland-dependent bird species such as Sprague's pipit, Baird's sparrow, chestnut-collared longspur and McCown's longspur (Lipsey 2015).

Grasslands of the APR region evolved under conditions of variable grazing pressure by bison and other herbivores. These herbivory patterns were responsive to variations in plant productivity and nutritional value caused by variable soil conditions, by variable precipitation patterns, and by occasional lightning- and human-lit prairie fires (Krueger 1986, Whicker and Detling 1988, Knopf and Samson 1997, Truett et al. 2001, Anderson 2006, Fuhlendorf et al. 2012). The result was a wide range of disturbance intensity that shifted annually across the landscape. Recently burned areas would temporarily be bare ground that then yielded nutritious new growth that was intensively grazed by bison, pronghorn and other herbivores. The next year bison and other herbivores would move on to other newly burned sites to graze while leaving the now less nutritious vegetation on the previous year's sites to grow ungrazed. Vegetation and thus fuel for the next fire would continue to grow for potentially many years in these undisturbed sites until fire once again marked the start of a new cycle. Prairie dog colonies added another type of disturbance to the landscape (Figure 2). At large scales this shifting mosaic of habitat diversity leads to ecological stability (Fuhlendorf et al. 2012). Moreover, it is of central importance to the diversity of plants, mammals, birds and other taxa (Fuhlendorf and Engle 2001, Truett et al. 2001, Samson et al. 2004, Anderson 2006, Jonas and Joern 2007), including numerous BLM Sensitive Species. Restoration of habitat heterogeneity directly addresses BLM Rangeland Health Standard #5 regarding the maintenance of healthy and diverse populations of native species, including the importance of ensuring that "a variety of age classes are present," that "the environment contains components necessary to support viable populations of a sensitive/threatened and endangered species in a given area relative to the site potential," and that "plant communities in a variety of successional stages are represented across the landscape."

Loss of such heterogeneity may be contributing to long-term population declines of several species of grassland-obligate birds, particularly those with breeding ranges centered on the Northern Great Plains (Knopf 1996) (Figure 2). Species found in the APR region that have

shown statistically significant population declines from 1966-2015 are (precision-adjusted estimates of population declines in parentheses, from Sauer et al. 2017): chestnut-collared longspur (-4.0%), McCown's longspur (-3.7%), mountain plover (-3.4%), Sprague's pipit (-2.9%), lark bunting (-2.5%), horned lark (-2.4%), bobolink (-2.0%), Baird's sparrow (-2.0%), savannah sparrow (-1.4%), western meadowlark (-1.3%), northern harrier (-1.2%), burrowing owl (-1.0%) and vesper sparrow (-0.9%). Nearly all of these are BLM Sensitive Species and Montana Natural Heritage Program Species of Concern. Based on research in the APR region, Lipsey (2015) proposes that a reasonable goal for conserving grassland bird diversity is to increase areas with extreme values in vegetative cover and that this is most effective if done over large grassland landscapes of at least 368,640 acres.

Rangeland management for bison must also address sage-grouse conservation needs. The bison's strong preference for grass forage and general avoidance of woody riparian habitats, even during summer, should be compatible with maintaining sage-grouse habitats, including shrub cover and herbaceous plants of varying heights. BLM's HiLine Management Plan, for example, calls for the reduction of summer grazing in riparian areas to help conserve sage grouse habitat.



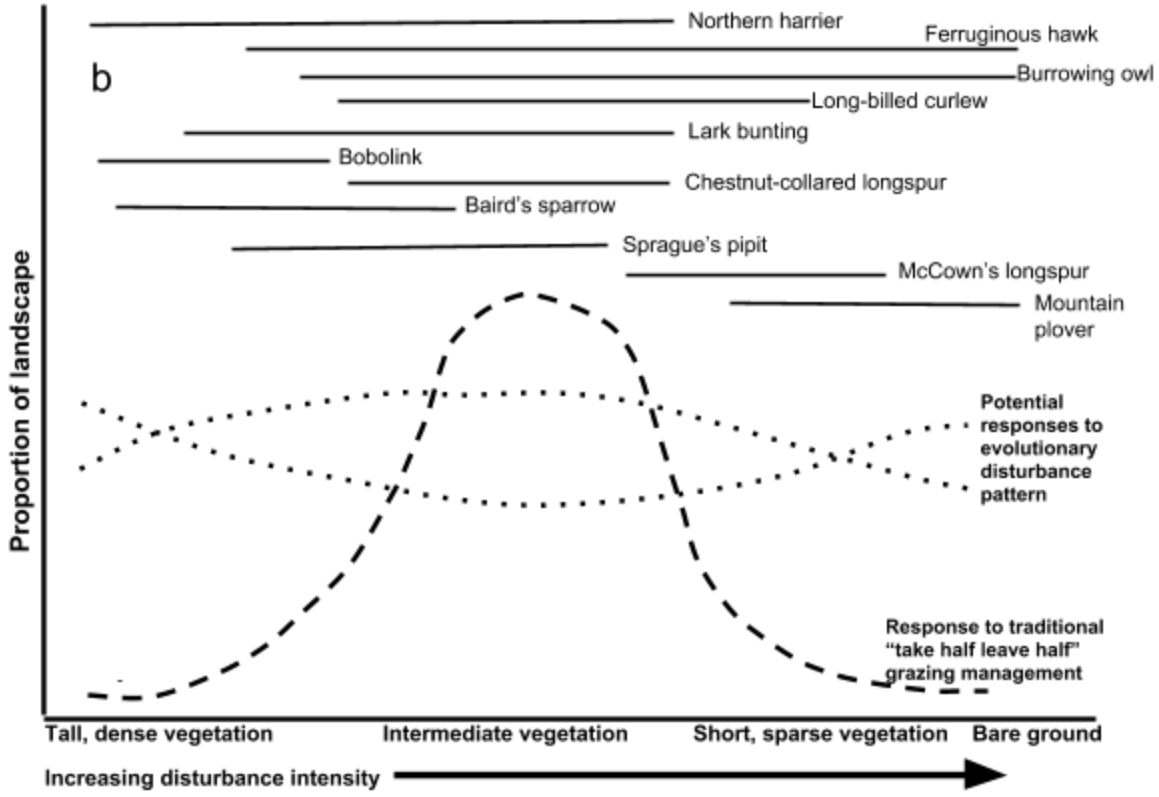



**Figure 2. a) General representation of postulated disturbance intensity across the landscape caused by bison grazing, fire and prairie dogs before Euro-American colonization of the Great Plains and by traditional "take half leave half" livestock grazing management. b) General representation of vegetation response to the two disturbance gradients and of selected bird species preferences for vegetation structure (horizontal line indicates range of preferred vegetation structure). The two vegetation responses to evolutionary disturbance patterns are shown to indicate that the proportion of each vegetation structure may vary considerably across the landscape and from year to year. See text for further explanation. Adapted from Knopf 1996, Fuhlendorf et al. 2008, Alberta Conservation Association 2017.**

Bison are a foundation species—species that have a disproportionate and often stabilizing effect on the diversity and structure of ecosystems (Dayton 1972, Ellison et al. 2005). Through grazing and other actions, bison have played a central role in the functioning of grassland ecosystems (Day and Detling 1990, Knopf and Samson 1997) in supporting the diversity of grassland plants, birds, mammals and other wildlife (Coppock et al. 1983, Knopf 1996, Gogan et al. 2010, Gross et al. 2010).

Arguably the two ecologically most important herbivorous mammals of the APR region and Great Plains generally were the bison and black-tailed prairie dog (Truett et al. 2001, Samson et al. 2004), and both, compared to other herbivorous mammals of the APR region, have

undergone severe population declines without any substantial recovery of wild populations since Euro-American colonization. (Within the Missouri Breaks habitat, bighorn sheep have suffered similar declines.).

Prairie dogs, a keystone species in the prairie ecosystem and a BLM Sensitive Species/Montana Species of Concern, interact with plant and animal species and ecological conditions in multiple ways. They are prey for dozens of species of predators, including swift fox, ferruginous hawk, golden eagle and black-footed ferret--all Montana Species of Concern and BLM Sensitive Species, except the ferret which is a BLM Special Status Species. Prairie dogs are crucial for survival of the highly endangered ferret. APR's Sun Prairie unit is 10 miles from a black-footed ferret recovery area on the UL Bend National Wildlife Refuge (within CMR Refuge) but recovery work has been stymied by the limited size of prairie dog colonies in the area and the negative effect of sylvatic plague on colony populations (USFWS 2017b).

Prairie dogs also create habitat heterogeneity and den sites for other species through burrowing and herbivory. The burrowing owl, a BLM Sensitive Species/Montana Species of Concern, nests in prairie dog burrows and mountain plovers, also a BLM Sensitive Species/Montana Species of Concern, frequently forage on prairie dog colonies. Prairie dog colonies and associated ungulate grazing create floristic communities and vegetative successional stages seldom found elsewhere in mixed-grass prairie. Changes in plant species composition and increased plant nutritional value in and around prairie dog colonies in mixed-grass prairie attract grazing by bison, elk and pronghorn. Bison grazing of grasses combined with nitrogen enrichment from bison urine leads to increased forb abundance and quality, which benefits pronghorn because of their preference for forbs. Grazing and browsing by bison and other species may reduce the height of vegetation, which facilitates prairie dog colonization (Coppock et al. 1983a, b, Coppock and Detling 1986, Krueger 1986, Knapp et al. 1999, Truett et al. 2001, Fahnstock et al. 2002, Augustine and Baker 2013, Chipault and Detling 2013).

Bison wallowing also creates disturbed sites and ephemeral pools of standing water, which support a variety of wetland plant species, particularly forbs (Collins and Uno 1983, Polley and Wallace 1986, Knapp et al. 1999), and provide breeding habitat for the Great Plains toad (Bragg 1940), a BLM Sensitive Species/Montana Species of Concern.

Populations of elk and pronghorn are likely below those of pre-Euro-American colonization. Their restoration to larger numbers will help restore ecological interactions with bison. Because the diets of pronghorn (primarily forbs and browse), elk (grass, forbs and browse) and bison (primarily grass) are different, their combined effects on vegetative composition and productivity are complex. In some cases, such as under conditions of drought and low plant productivity and (or) high ungulate densities, they may compete with each other for forage. In other circumstances, foraging by one species may increase forage availability for another. For example, reduction in grass cover due to foraging by bison may reduce competition with--and thus increase productivity of--forbs for pronghorn (bison wallows also favor forb production).

Similarly, reduction in shrub cover due to browsing by elk and pronghorn may result in more grass for bison (Hobbs et al. 1996, Truett et al. 2001, Weisberg et al. 2002).

***Fence Effects on Wildlife***

Many grassland species require a two-dimensional landscape. Novel vertical structures--fences, trees, buildings, utility lines--that are higher than native prairie vegetation fragment the landscape with diverse negative effects on wildlife. Fences alter natural foraging patterns, movements and migration of ungulates which may reduce reproduction and survival (Harris et al. 2009, Whyte et al. 1988, Gates et al. 2012). The wide-ranging foraging behavior of bison are highly constrained by cross-fencing that creates small grazing units (Kohl et al. 2013). Entanglement in fences is a common cause of mortality in pronghorn, bighorn sheep, mule deer and elk (Harrington and Conover 2006). Movements and habitat use by pronghorn are strongly influenced by fence location and density, and long-range migration routes, such as those undertaken by pronghorn in the HiLine region of Montana (Poor et al. 2014), are disrupted by fencing. Fencing may prevent migrating pronghorn from reaching higher quality habitat, causing them to expend energy walking fencelines without finding better conditions (Oakley and Riddle 1974, Ockenfels et al. 1994, Berger 2004, Sheldon 2005, Collins 2016).

Fence collisions kill a diversity of avian species (Allen 1990, Paige 2012) and are a potentially important source of mortality in greater sage-grouse populations (Call and Maser 1985, Allen 1990, Connelly et al. 2000, NRCS 2012, Stevens et al. 2012, 2013). This is of particular concern in the Hi-Line/APR region of Montana, a nationally important area for sage-grouse populations (Doherty et al. 2010) and where sage-grouse have been shown to undertake annual migrations of 50-100 km (31-62 miles) between lek areas and winter habitat (Tack et al. 2011). For many grassland birds, fences and other novel vertical structures, which may serve as perches for raptors or for nest parasites such as cowbirds, reduce nesting and brood rearing success (Freilich et al. 2003, Shaffer et al. 2003, Coppedge et al. 2008).

Three- and four-stranded barb-wire fences and mesh woven fences are common in Montana's Hi-Line region, with an estimated average fence density 3.8 miles/sq mile in 2009 (Poor et al. 2014). To restore habitat contiguity, APR's goal is to remove all interior fencing and to install wildlife-friendly fencing on all perimeter fencing.

APR perimeter fence design is based on design recommendations from NRCS and MFWP (Paige 2012, NRCS 2012).

***Need to Conserve Bison***

*i. Taxonomic status:* Two subspecies of American bison are recognized, wood bison (*Bison bison athabascae*) and plains bison (*B. bison bison*). Plains bison is the subspecies native to the Great Plains, including the APR region (Boyd et al. 2010b).

*ii. Legal status:* Bison in Montana are classified as either "domestic livestock" or "game animal." According to Montana statutes (Montana 2017a,b), "'domestic bison' means a bison owned by a

person." And "'Game animals means deer, elk, moose, antelope, caribou, mountain sheep, mountain goat, mountain lion, bear, and wild buffalo." The statutes then clarify the definition of wild buffalo by stating "Wild animal means an animal that is wild by nature as distinguished from common domestic animals, whether the animal was bred or reared in captivity, and includes birds and reptiles." APR-owned bison are therefore legally "domestic bison," which, like other domestic livestock, fall under the regulatory jurisdiction of MDL. The only "wild bison" in Montana are bison in Yellowstone National Park that move beyond the park boundary in Montana (MFWP 2015a).

The legal status of bison as livestock or wildlife or both at the federal level in the U.S. and Canada and among other states and provinces varies widely and need not be reviewed here (Aune and Wallen 2010). The National Bison Legacy Act in 2016, citing, among many other findings, the bison's importance as a "historical symbol of the United States," its "benefit to grasslands," and its "historical, cultural and economic significance...to the heritage of the United States," designated the American bison as the official mammal of the United States.

*iii. Conservation status:* The plains bison and its ancestors have been coevolving with the grassland habitats and wildlife of North America for roughly 100,000 years. Until their extermination from the region in the 1880s, plains bison grazed the landscapes of Montana's northern plains since the last of the ice sheets of the Wisconsin glaciation retreated from the region about 12,000 years ago (Potter et al. 2010). Plains bison once numbered in the tens of thousands in this region and was a "foundation species," meaning that, through grazing and other actions, the bison strongly influenced the structure of the grassland ecosystem, including habitats of importance to grassland plants, birds, mammals and other wildlife (Gogan et al. 2010, Gross et al. 2010). As the Natural Resource Conservation Service (NRCS) guide to grassland bird management notes (NRCS 1999, p. 5), "Grazing bison in the west was once a natural means of grassland management." The accounts of Lewis and Clark and other early explorers, as well as diverse artifacts such as buffalo jumps, testify to the former abundance of bison in the APR region (Laliberte and Ripple 2003). Bison were clearly an important factor in shaping the ecological conditions of the region's grasslands, soils and waters for thousands of years (Gates et al. 2010, Potter et al. 2010). Now, however, a majority of conservation herds of bison are small (fewer than 500 individuals) and found in a few small, fenced protected areas in the Great Plains without the full complement of predators and other species with which bison historically interacted (Gates and Ellison 2010, Gates et al. 2010). Bison are therefore no longer the foundation species affecting in diverse ways millions of acres of Great Plains grasslands--they are for the most part ecologically extinct (Freese et al. 2007). Moreover, except for APR, no Great Plains park or reserve--public, private or nonprofit--has the explicit goal of restoring bison and the full complement of other species with which they co-evolved (Freese 2015).

The total number of plains bison in North America was reduced to roughly 200 animals by the 1890s, precariously close to extinction (Gates and Ellison 2010). Concerns about the bison's plight led to efforts in the early 1900s to establish bison conservation herds. By the 1930s

approximately 20,000 bison were in several conservation herds spread across the U.S. and Canada. The number in conservation herds has not changed substantially since that time. Moreover, nearly all conservation herds today consist of fewer than 500 animals, raising concerns about genetic diversity and long-term genetic health of the herds. In addition, cross-breeding efforts with domestic cattle around the turn of the Century resulted in most conservation herds today harboring a small amount of cattle genes in their DNA (Freese et al. 2007, Boyd et al. 2010a, Gross et al. 2010).

Because of these concerns about bison genetics and loss of the bison's ecological role in grasslands, there is broad agreement that extraordinary efforts are required to restore large bison herds. The state of Montana lists the plains bison as a Species of Greatest Conservation Need (MFWP 2015b) and the Montana Natural Heritage Program designates it as a Species of Concern with a G4 global ranking and S2 state (Montana Natural Heritage 2016).[1] The IUCN Red List designates the American bison as "near threatened" (Gates and Aune 2008). The Committee on the Status of Endangered Wildlife in Canada has designated the plains bison as "threatened" (COSEWIC 2013). Calls for bison restoration span multiple stakeholders, from the U.S. and Canadian governments (COSEWIC 2013, DOI 2014) and state of Montana (MFWP 2015a) to private ranchers (NBA 2016), Indian Tribes (ITBC 2016), nonprofit organizations (NWF 2016), bison scientists (Sanderson et al. 2008) and the international conservation community (Gates et al. 2010).

Bison restoration is inextricably hitched with both the ecological and human dimensions of biodiversity restoration and conservation on APR. Grazing was a keystone process that shaped Great Plains grasslands and the evolution of their biota for thousands of years, and bison have been the primary grazer in this process. Accordingly, bison have been designated as a "keystone" or "foundation" species because of their inordinately large influence through grazing and other interactions on biodiversity of Great Plains grasslands (Milchunas et al. 1988, Knapp et al. 1999, Gross et al. 2010).

Bison are highly adaptable habitat generalists, as evidenced by their historically wide geographic range and the diversity of habitats they inhabit (or once inhabited), from the Canadian boreal forest to Chihuahuan desert and nearly spanning the continent from coast to coast (Potter et al. 2010). Bison are also a highly interactive "foundation species" of the APR region. An important challenge for the conservation of foundation species is to determine and subsequently achieve an ecologically effective population density--the density required for a foundation species to display the effects it has on an ecosystem under natural conditions.

[1] The international network of Natural Heritage Programs employs a standardized ranking system to denote "global" (G) (range-wide) and "state" (S) status. Species are assigned numeric ranks ranging from 1 (highest risk, greatest concern) to 5 (demonstrably secure, least concern), reflecting the relative degree of risk to the species' viability, based upon available information. See cited publications for more information.

Failure to reach this size may result in ecosystem degradation and biodiversity loss (Soule et al. 2003).

APR's bison management objectives incorporate criteria of the Sanderson et al. (2008) scorecard for making an "exceptional contribution" (the highest category) to fulfilling the goals of the "Vermejo Statement" on ecological recovery of bison.

Bison have inhabited and continuously grazed the plains of eastern Montana since the retreat of the last continental ice sheet 12,000 years ago. About 150 years ago they were replaced by domestic livestock and became ecologically extinct because the few herds remaining were too small, confined and isolated to exert the ecological roles they once had in the Great Plains (Freese et al. 2007).

Under coordination by the InterTribal Bison Cooperative (ITBC), bison restoration is also a priority for cultural, spiritual, ecological and economic purposes on Indian lands.

Minimizing manipulation of the bison population to allow the population to develop a natural sex ratio and age structure is important for enabling bison to fully express their natural behavior and ecological relationships. Social relationships, including mate selection by cows and mating competition among bulls, cow-offspring relationships, and overall herd social structure and interactions are important for allowing "bison to be bison" as well as for enabling natural selection and long-term evolutionary change in bison. Natural herd movement in relation to forage, water, landscape features, predation risk and other factors may have significant effects on the grassland ecosystem.

Genetic variation (heterozygosity and number of alleles) is important for the fitness of individual animals and provides the mechanism for evolutionary change and adaptation of populations (Allendorf and Leary 1986, Boyd et al. 2010a). Four interrelated mechanisms can reduce genetic variation: demographic bottlenecks, founder effects, genetic drift and inbreeding. Bison have been subjected to all of these mechanisms since their near extinction in the late 1800s. Despite these potential problems, plains bison appear to have retained good genetic variation at levels similar to other North American ungulates. Moreover, significant differences in genetic variation exist among public conservation herds (Wilson and Strobeck 1999, Halbert 2003, Halbert and Derr 2008, Boyd et al. 2010a). However, because only approximately 20,000 plains bison occur in roughly 55 conservation herds, and a large majority of those herds number fewer than 400 individuals, genetic conservation of plains bison remains a concern and a conservation priority (Gates and Aune 2008, Boyd et al. 2010a, Dratch and Gogan 2010).

Another concern regarding bison genetic conservation is artificial selection for certain traits. More than 400,000 plains bison in North America are in private commercial herds. Herds undergoing purposeful selection for domestication and commercial purposes, such as docility and a particular body conformation, can develop genetically determined differences in morphology, behavior and physiology compared to wild populations (Boyd et al. 2010a).

Bison were crossbred with cattle at the turn of the 20th century in hopes of creating a mixed breed with the handling and commercial benefits of cattle and the hardiness of bison. The legacy of this unsuccessful effort is that fewer than 7,000 plains bison in North America display no evidence of cattle gene introgression. Although the amount of cattle genes is generally low—less than 2% in most non-commercial conservation herds—and bison with low levels of cattle genes look like wild bison, there has been little research to assess what effects, if any, cattle genes may have on bison. Some cattle genes, particularly those in the mitochondria, for example, might affect the metabolism of bison, which, unlike cattle, slows down significantly in winter. Bison with cattle mitochondrial DNA may have a smaller body size than bison without mitochondrial DNA (Hedrick 2009). Maintenance and growth of cattle-gene-free bison conservation herds is considered a priority (Gates and Aune 2008, Hedrick 2009, Boyd et al. 2010a, COSEWIC 2013).

Maintaining genetic variation is also important because reduced variation may constrain the ability of bison to evolutionarily adapt through natural selection to new or evolving disease pathogens and to changing ecological conditions due to climate change and other factors (Hoffmann and Sgró 2011, Vander Wal et al. 2014)

APR's goals for the size of its bison population and for conserving bison genetics address the above threats to conserving the wild bison genome. A relaxed goal of a 90% probability of retaining 90% of selectively neutral genetic variation over 200 years can likely be met with a census population of 1,000 bison, assuming equal number of bulls and cows and a stable population size (Gross et al. 2010). This is the level recommended by the Department of the Interior for federal herds (Dratch and Gogan 2010). Hedrick (2009) recommends a census population 2,000-3,000 to avoid inbreeding depression and loss of genetic variation.

APR's goal for bison genetics includes close collaboration with managers of other conservation herds in North America to support the development of multiple herds that, collectively, will help restore and maintain the genetic variation and integrity of the plains bison.

***APR BIson Population Estimates and Stocking Plans***

Table 1. Projected mid-year total bison population, animal units and associated carrying capacity of current APR management units, 2016 - 2030. Acquisition of additional properties will greatly increase future cumulative carrying capacity beyond what is shown here. Population projections are based on planned herd size controls during 2018 and 2019 and, for 2020 and beyond, on a 20% annual rate of population growth. Per BLM regulations, calves of the year (calves <6 months) are excluded from estimated animal units. Carrying capacity for all years on BLM and State lands is based on their current permitted and leased AUMs; deeded land carrying capacity is based on NRCS guidelines for "normal" precipitation for 2016-2018 and for "below normal" precipitation for 2019 and beyond. Abbreviations: SP = Sun Prairie, SPN (Sun Prairie North), DF (Dry Fork), WR (White Rock), TWO (Two Crow), B (Beauchamp), BL (Burnt Lodge), CK (C.K. Creek), PN (PN), TC (Timber Creek). *Supplemental feeding provided

because animals temporarily exceeded carrying capacity. **Upon 2019 approval by BLM and DNRC of APR's Proposed Action.

| Year | Estimated mid-year total population | Estimated animal units | Year's end projected management units with bison (deeded + leased unless indicated otherwise) | Cumulative carrying capacity (animal units for 12 months) |
|---|---|---|---|---|
| 2016 | 728 | 540 | SP, 3,900 deeded acres SPN | 502* |
| 2017 | 864 | 699 | SP, 3,900 deeded acres SPN, and 5,900 deeded acres DF | 649* |
| 2018 | 850 | 829 | SP, 3,900 deeded acres SPN, 5,900 deeded acres DF, and 7,350 deeded acres WR | 894 |
| 2019 | 955 | 816 | SP, SPN, DF, WR | 1,452** |
| 2020 | 1,150 | 917 | SP, SPN, DF, WR, | 1,452** |
| 2021 | 1,363 | 1,104 | SP, SPN, DF, WR | 1,452** |
| 2022 | 1,636 | 1,308 | SP, SPN, DF, WR | 1,452** |
| 2023 | 1,963 | 1,571 | SP, SPN, DF, WR, TWO | 2,050** |
| 2024 | 2,356 | 1,884 | SP, SPN, DF, WR, TWO | 2,050** |
| 2025 | 2,827 | 2,262 | SP, SPN, DF, WR, TWO, PN | 2,783** |
| 2026 | 3,391 | 2,714 | SP, SPN, DF, WR, TWO, PN | 2,783** |
| 2027 | 4,069 | 3,255 | SP, SPN, DF, WR, TWO, PN, TC | 4,410** |
| 2028 | 4,883 | 3,906 | SP, SPN, DF, WR, TWO, PN, TC | 4,410** |
| 2029 | 5,860 | 4,688 | SP, SPN, DF, WR, TWO, PN, TC | 4,410** |
| 2030 | 7,032 | 5,626 | SP, SPN, DF, WR, TWO, PN, TC , BL, B, CK | 4,631** |

Table 2. APR management units with breakdown of deeded and leased BLM and state acres, carrying capacity (in BLM animal units, thus excluding calves <6 months old), and years/projected years of first bison reintroductions, based on assumption that BLM and DNRC

will approve APR's requested change of use. All APR deeded/leased lands are not slated for bison reintroduction and thus totals given here are less than total APR acres. However, plans may be subject to change with the acquisition of new properties or other unforeseen circumstances. *The animal units were derived by using the NRCS method for calculating carrying capacity at "below normal" precipitation for APR deeded land and then adding the permitted and leased AUMs for BLM and State lands. Bison introduction dates may change if approved by BLM and State or as changes in APR land ownership dictate.

| APR Unit | BLM acres | State acres | Deeded acres | Total acres | Carrying Capacity (Animal Units for 12 Months)* | 1st bison reintroduction |
|---|---|---|---|---|---|---|
| Sun Prairie | 18,034 | 640 | 8,911 | 27,585 | 356 | 2005 |
| Sun Prairie North | 13,075 | 640 | 7,075 | 20,772 | 212 | 2016 on 3,900 acres of APR deeded |
| Dry Fork | 15,445 | 680 | 8,013 | 24,138 | 327 | 2017 on 5,900 acres of APR deeded |
| White Rock | 21,121 | 3,492 | 12,432 | 37,045 | 557 | 2018 on 7,350 acres of APR deeded |
| Two Crow | 38,073 | 3,200 | 5,002 | 46,275 | 598 | 2023 |
| PN | 16,562 | 10,034 | 20,764 | 47,360 | 733 | 2025 |
| Timber Creek | 130,399 | 9,343 | 18,178 | 157,920 | 1,627 | 2027 |
| Beauchamp | 2,375 | 640 | 961 | 4,336 | 47 | 2030 |
| Burnt Lodge | 5,245 | 640 | 4,495 | 10,380 | 161 | 2030 |
| C.K. Creek | 204 | 0 | 613 | 817 | 13 | 2030 |
| Total | 260,893 | 29,309 | 86,426 | 376,628 | 4,631 | |

***Need to Conserve Fully Functioning Grassland Ecosystems***

Temperate grasslands or savannas have historically made up approximately 30% of the Earth's landmass, but are currently considered among ecosystems that are the most threatened by conversion or degradation, with less than 50% remaining intact (Sala et al. 2000, Hoekstra et al. 2005). In western North America, the loss of native grazers, inappropriate livestock management practices, and human-driven land conversion or degradation have resulted in steadily declining biodiversity and rangeland health (Dreitz et al. 2017). These global and regional trends have resulted in grasslands being cited among the world's biomes in crisis (Hoekstra et al. 2005). In response, the conservation and restoration of grassland ecosystems has become a popular theme in rangeland ecology (Fuhlendorf and Engle 2001, Briske et al. 2005, Havstad et al. 2007).

Temperate grasslands are one of the most threatened and, with 4% in protected status, are the least protected of the world's terrestrial biomes (Coad et al. 2009). Reflecting this situation, just 1% of the Great Plains is in protected areas (CEC and TNC 2005). Tillage for crop production, which continues at a rapid pace in many regions, including the Northern Great Plains, is the most severe threat to temperate grasslands. Poorly managed livestock production, also increasing globally, is the next biggest threat to grassland health and biodiversity. As a result, grassland species and grassland health are declining globally (Samson et al. 2004, MEA 2005).

The glaciated plains of the APR region has been identified as a global priority for conserving grassland biodiversity because of the diversity of its flora and fauna and the relative intactness of its native habitats (Forrest et al. 2004, CEC and TNC 2005). But many species and habitats are under threat.

At least 74% of 39 species classified as grassland obligates with distributions centered in the Northern Great Plains are listed as imperiled by federal, state and provincial governments (Forrest et al. 2004). Among carnivores and ungulates, grasslands lost more species across larger parts of their range than any other biome in North America (Ripple et al. 2013). Apart from the plight of bison, populations of pronghorn, elk and bighorn sheep are suppressed far below pre-Euro-American colonization levels and likely below what the habitat could currently support (Laliberte and Ripple 2004). Elk are largely ecologically extinct in the Northern Great Plains. Of the four large carnivores native to the APR region, only cougars and black bears are extant, though likely in suppressed numbers (Laliberte and Ripple 2004).

Smaller species are also at risk. The population of one keystone species of the mixed-grass prairie, the black-tailed prairie dog, has been reduced to 2% of its former range, including in the APR region (Forrest 2005). APR is within the Great Plains region recognized for the highest diversity of grassland-dependent bird species, but several of these species are exhibiting significant population declines (Sauer et al. 2017). Overall, among animals, 62 "Species of Concern"—9 mammals, 35 birds, 5 reptiles, 2 amphibians, 10 fish and 1 insect—occur in the APR region, as well as several plant species that are species of concern (Montana Natural Heritage 2016). The region is recognized for its high diversity of grassland-dependent bird

species, but 12 of these and other grassland bird species in the region have displayed significant population declines ranging from an estimated 0.9% to more than 4.0% annually from 1966-2015 (Sauer et al. 2017).

Thousands of acres of habitat for grassland species are being lost annually in the APR region. During 2014 - 2015, Blaine, Phillips, Valley and Garfield counties each lost more than 18,000 acres of grassland that were converted to crops, the continuation of a long-term trend (Gage et al. 2016). From 2007 - 2015, contracts were not renewed on more than a half million acres of Conservation Reserve Program lands in the seven-county region of APR (USDA 2016); an unknown proportion of this land likely returned to crop production. In addition to being a massive loss of habitat for bison and other native grassland species, the conversion from grassland to cropland has far-reaching effects on soil and water resources. Cultivation disrupts soil structure, increases decomposition rates, accelerates soil erosion and degrades grassland streams and rivers in the region (Ogle et al. 2005, Teply 2013). Cultivation of native grassland in the Northern Plains results in an estimated soil loss of 4.16 – 5.49 tons/acre/year (USDA SCS 2000, FAPRI 2007), massive loss of nitrogen and phosphorus, and the loss of 50% or more of soil organic carbon (Hartman et al. 2011). Historically, when bison were abundant in the Great Plains, soil carbon was likely maintained with little variation (Wang et al. 2014). In semi-arid grasslands such as are found in the APR region, moderate to heavy stocking rates appear to result in greater soil carbon storage than light or no grazing, but excessive stocking rates can reduce soil organic carbon (Conant 2010).

Hydrologic systems of the region have been extensively and intensely altered, with most streams and riparian areas highly degraded and water quality and aquatic organisms negatively impacted (Teply 2013). These and many other factors discussed below provide the rationale for a broad, ecosystem-based approach to bison conservation.

Restoring the bison's ecological role may, among other measures, help restore and conserve both biodiversity and the soil and water resources of the grassland ecosystem. Nearly all lands acquired and leased by APR will have previously been used for livestock production and to a lesser extent for crop production. These commodity production lands create ecological conditions that to varying degrees are inimical to native biodiversity (Freese et al. 2014). Monoculture croplands, mostly wheat, are common and increasing as previously native prairie and former Conservation Reserve Program lands continue to be newly cultivated for production with resulting degradation of soils and streams. Most of the lands used for livestock production are cross-fenced and have numerous stock ponds and other watering installations to facilitate rotational and uniform grazing practices. Non-native grasses such as crested wheatgrass are common on upland sites and hay fields of other non-native plant species common in lowland areas. Fire suppression is the general practice. Hydrological engineering is extensive, with stock ponds ubiquitous across the landscape in the upper reaches of watersheds and check dams and spreader dikes common across lowland areas. Numerous forms of infrastructure--roads, fences, old homestead buildings, utility poles and lines, dams, cultivated land and so on--fragment the habitat.

A 1994 BLM report indicated that rangeland ecosystems are still “not functioning properly in many areas of the West. Riparian areas are widely depleted and some upland areas produce far below their potential. Soils are becoming less fertile.” The agency concluded that riparian areas have ”continued to decline to their worst condition in history” (BLM 1994, cited in Regan 2016). A 2012 BLM report noted that nearly one-quarter of allotments are not meeting or making significant progress toward BLM rangeland health standards (BLM 2012, cited in Regan 2016), a condition generally corroborated by others (PEER 2017). To the extent that some of these problems exist on BLM allotments in the APR region (detailed rangeland health assessments by BLM in the area are not available), APR believes their bison grazing proposal can help resolve them. In addition, the value of federal rangelands has increased with the new and evolving demands for environmental uses (Regan 2016). This argues that grazing permits should be allowed to migrate to their highest value use, whether that is livestock grazing, bison grazing or wildlife conservation.

APR could meet many of its goals, such as bison population size and genetic diversity, by artificially feeding and intensively managing the bison population under artificial conditions. But the ecological context matters for many bison-specific management goals and, more broadly, for meeting APR’s mission of restoring and conserving native biodiversity under natural conditions.

To get the ecological conditions right, APR has established the Freese Scale for Grassland Biodiversity, adapted from a paper by C.H. Freese, S.D. Fuhlendorf and K. Kunkel that proposed a management framework for the transition from livestock production toward biodiversity conservation on Great Plains rangelands (Freese et al. 2014). The Freese Scale covers ten ecological conditions that are important to restore in the transition from agriculture-centered management to biodiversity-centered management on Great Plains rangelands. Rangeland management practices that focus on commodity production alter these conditions in ways that create management efficiencies and that direct more primary and secondary production toward the desired commodities (e.g., grains, beef). In many cases such management results in the loss of native species and other forms of biodiversity degradation. The most serious losses occur when native grassland is converted to crop production.

Fortunately, state and federal landowners as well as many private landowners in the APR region have maintained much of the land in native grassland and other native habitat for livestock grazing. With good management that maintains the right ecological conditions, many species of wildlife do well on these lands. Nevertheless, even in these situations a few species and some important ecological processes tend to lose out when commodity production is a major driver (Fuhlendorf and Engle 2001). APR’s goal is to restore the most important ecological conditions and processes that existed before agricultural use of the land and thereby create conditions for restoring viable populations of all native species.

Restoration of native habitats and plant diversity is intrinsically important for conserving and offering the public the chance to experience the biodiversity of this region. A plant inventory of Phillips and Valley Counties recorded 717 species, 358 genera and 86 families, and 32% of the species were first records for the two counties (Charboneau et al. 2013).

Species-diverse grasslands are resilient to drought in the face of climate change (Craine et al. 2013). In many respects, restoring and maintaining native plant communities and thus the ability of the land to adapt to changing environmental conditions is the foundation for all other goals aimed at restoring and conserving natural ecological conditions.

APR has implemented a comprehensive weed management plan that identifies priorities and addresses methods of prevention and control. Four main methods are employed for controlling non-native plant species: mechanical, chemical, biological, and fire. APR conducts its own weed monitoring, assessment and control work as well as enlisting the cooperation of County Weed Districts and private contractors to assist in weed control.

APR has three main categories of high priority infestations:

- *Isolated infestations*: These infestations are usually high priorities, even for species that do not pose the greatest impact to the property's resource base. All weed infestations that are under 0.1 acre in size are priority for eradication.
- *Patches of highest priority weed species and that, if left alone, would soon be uncontrollable*: Leafy spurge spreads rapidly and thus is a priority for control as soon as it observed. Large infestations of leafy spurge are difficult to control.
- *Roadsides, parking areas, trails, ditches, dams, and streams*: Weed infestations in these areas are high priorities for control because they experience frequent disturbance, which creates favorable habitat for weed establishment and spread, and because vehicles and water are two of the most common agents for spreading weeds. Infestations of new weed species may first appear in disturbed sites such as road edges, ditch banks and stream banks. Vehicles traveling along roads and trails can spread weed seeds to other areas. Livestock and wildlife may transport seeds in their digestive systems and fur.

Species with large home ranges and/or that occur at low population densities, such as bison, golden eagles and large carnivores, require large areas to accommodate their movements and to support viable population sizes. Large-area requirements, however, are not limited to these species. Conserving a high diversity and abundance of small grassland birds in the APR region depends on grassland structural diversity at large landscape scales of several hundred thousand acres (Lipsey 2015). Nearly all native species require or do best with large tracts of native habitat without fragmentation. Every acre of land purchased by APR prevents its potential conversion to cropland and, if already in cropland, enables APR to restore it to native grassland habitat.

Large management units are especially important for bison restoration because natural bison behavior and grazing patterns, particularly when interacting with the shifting habitat mosaic generated by fire, variable precipitation patterns, and other factors, require large landscapes of tens of thousands to hundreds of thousands of acres. Large-scale ecological processes such as pyric herbivory and natural stream flows require large landscapes. A large reserve more readily accommodates habitat complexity and disturbances that interact with complex landscapes to form multi-scale habitat mosaics (Sanderson et al. 2008, Gates et al. 2010, Fuhlendorf et al. 2012). No existing public or nonprofit nature reserve in the Great Plains is sufficiently large or appropriately configured to readily accommodate all native species and associated large-scale ecological conditions and processes of these historic grasslands (Freese 2015).

No reserve can stand alone and maintain its native biodiversity for long. Wildlife migrations, large-scale ecological processes and encroachment of unfavorable human influences require that reserves be buffered by reserve-friendly lands and that ecological corridors or stepping stones be available to enable gene flow among populations, to accommodate migratory species, and to facilitate adaptation and range shifts caused by climate change (Soulé and Terborgh 1999, Alagador et al. 2016, Freese et al. 2016).

Bison biologist Dale Lott, in his book *American Bison: A Natural History*, suggested that “A Great Plains Park must be very large--at least 5,000 square miles--and must include both upland and river bottom habitat” (Lott 2002, p. 203). APR’s goals for the reserve fulfill Lott’s vision both in terms of habitat complexity and size (5,000 square miles = 3.2 million acres). Reaching the goal of 3.5 million acres for the core of the reserve requires that APR closely collaborate with the CMR Refuge, BLM and DNRC to achieve seamless management across jurisdictional boundaries. *Full Disclosure* - The late Dr. Lott was an early supporter of APR’s vision; he provided financial support, served as an expert on early fundraising safaris, and began research to write a book about the reserve. A plaque memorializing Dr. Lott’s inexhaustible commitment to bison conservation and APR is mounted on a boulder overlooking a valley commonly grazed by bison on the reserve.

Climate change will increasingly be a major driver of land management decisions and of socioeconomic conditions in the grassland ecosystems of North America’s Great Plains. The Northern Great Plains has already experienced some of the greatest increases in temperature in the continental U.S. in recent decades, increases that are projected to continue with multiple effects on agriculture, biodiversity and the socioeconomic wellbeing of its residents (USGCRP 2014).

Land use, particularly agriculture, forest management and rangeland management, contributes an estimated 24% of direct GHG emissions and thus has a pivotal role in addressing climate change (IPCC 2014). Improved land use can reduce GHG levels by reducing emissions and by removing $CO_2$ from the atmosphere via photosynthesis and sequestering the carbon in organic material. With rangelands covering 40% of the Earth’s land surface, storing 50% more carbon

than forests worldwide, and storing around 20% of global soil organic carbon (SOC), their wise stewardship is crucial for mitigating climate change (Conant 2010).

Effects of grazing on SOC loss are highly variable under different ecological conditions and different grazing intensities and histories. Moderate to heavy grazing in semi-arid grasslands of the Great Plains, where there is an evolutionary history of large ungulate grazing, appears to often result in greater SOC storage compared to ungrazed areas (Conant et al. 2001, Derner et al. 2006, Reeder et al. 2004). No significant difference in carbon sequestration has been found between rotational and continuous grazing on native rangelands (Eagle et al. 2012).

Effects of grazing on SOC, however, are highly site specific and can vary widely among apparently similar sites. This has led to broad consensus that the interaction of abiotic and biotic factors—rainfall patterns, temperature, soil conditions, plant communities, grazing history and so on—will usually override the effects of current grazing management on SOC. Consequently, except in circumstances where grazing has clearly degraded the grassland community and soil, grazing management is generally not considered a reliable method for managing carbon sequestration rates, especially over time periods of a few years (Derner and Schuman 2005, McDermot and Elavarthi 2014, McSherry et al. 2013, Wilcox et al. 2015). There is no clear evidence that the net effect of patch fires on SOC and GHG emissions in grassland systems is significantly positive or negative. Where periodic fires and grazing are allowed to interact (pyric herbivory), primary productivity generally increases, which suggests maintenance or an increase in SOC (Fuhlendorf et al. 2011). Even in the absence of fire most carbon in above-ground growth in grasslands ends up in 1 – 2 years cycling through to the atmosphere as $CO_2$ via plant decomposition and consumption by herbivores (heterotrophic transpiration) (Follett 2001).

Approximately 26% of $CH_4$ emissions in the U.S. are from enteric fermentation, primarily from ruminants (EPA 2015b). All native and nearly all domestic ungulate grazers in the Great Plains are ruminants. Thus, the historical switch in principal grazers from bison to cattle on rangelands has probably had a minor effect on $CH_4$ emissions. One analysis estimated that pre-Euro-American-settlement emissions from bison, elk and deer were 86% of current emissions from livestock (assuming a pre-settlement bison population of 50 million) for the continental U.S. (Hristov 2015). Another estimated a 14% lower $CH_4$ emission rate from 30 million pre-settlement bison than from 36.5 million cattle currently in the historic range of bison (Kelliher and Clark 2010). Cattle feedlots, however, contribute significantly to $CH_4$ emissions from manure (EPA 2015b).

Because Great Plains ecosystems and species evolved under boom-and-bust climatic conditions, the region's biodiversity may be pre-adapted to withstand the greater extremes that climate change portends. Compared to the ecologically homogenized landscape of agriculture—particularly crop production—a biologically diverse landscape offers the best chance for ecological adaptation to climate change. The diversity of native grasses and forbs may be crucial for enabling pre-adaptation and thereby for creating ecosystem resilience to climate change. Grass species in grassland systems display a broad range of tolerance to

drought—up to a ten-fold difference among species. Where high grass diversity is maintained, grasslands may be resilient to climate change because drought-tolerant species can replace less drought-tolerant species as drier conditions prevail. Thus high grass diversity may be crucial for maintaining ecosystem function, including the capacity for GHG mitigation (Craine et al. 2013).

Compared to livestock, native ungulates demonstrate greater tolerance to climatic extremes and should exhibit greater resilience to projected climate change in the Northern Great Plains. Tolerance to water scarcity by bison (Christopher et al. 1978, Kohl et al. 2013) may make them adaptable to predicted warmer and drier conditions. However, hotter temperatures may lead to increased nutritional stress for grazers as increased $CO_2$ levels may lead to decreased protein concentrations in grass forage; grazers may respond by increasing consumption of nitrogen-fixing forbs (Craine 2013, Craine et al. 2015).

Large and genetically diverse populations of plant and animal species increase the potential for them to evolve and adapt, thereby enhancing ecosystem resilience to a changing climate (Sgrò et al. 2011). A resilient ecosystem, in turn, will better maintain an ability to mitigate GHG emissions than a degraded ecosystem. Species adaptation to climate change may also require range shifts and thus large areas and ecological corridors of suitable habitat are also important (Alagador et al. 2016). This is already apparent among migratory birds of the Northern Great Plains as most species are arriving earlier on their breeding grounds and/or shifting their breeding ranges further north (Hitch and Leberg 2007, Johnsgard 2015, Swanson and Palmer 2009, Travers et al. 2015).

As APR becomes an increasingly prominent landowner and land manager in the Great Plains, it has an extraordinary opportunity to provide leadership in managing grasslands for climate change mitigation and adaptation on a large scale (Freese et al. 2016).

***Bison and Cattle Interactions***

What are the effects of grazing bison and cattle simultaneously on the same rangeland? Bison and cattle exhibit spatial segregation on rangelands because bison range widely across the landscape whereas cattle are central place foragers and commonly focus grazing around water sources (van Vuren 2001, Allred et al. 2011, Ranglack et al. 2015). Nevertheless, the potential for exploitative competition (one species' consumption decreases forage available for another species) and interference competition (physical displacement of one species by another) between cattle and bison exists. Intense summer grazing by bison of cattle winter range in the Henry Mountains of Utah likely created short-term reductions in forage availability, but no differences in plant community composition or productive potential was found compared to areas used by cattle only and to sites totally ungrazed by cattle and bison (Ware et al. 2014). Also in the Henry Mountains, lagomorphs were found to account for 34%, bison 14% and cattle 52% of the total grass biomass removed by all herbivores on the shared range, and thus cattle faced greater competition from lagomorphs than from bison in the study area. At least in the

Henry Mountains, purported effects regarding the negative impacts of bison on cattle appear to have been overstated (Ranglack et al. 2015).

Interference competition between cattle and bison is minor to nonexistent. In the Henry Mountains of Utah, where bison and cattle have coexisted since the 1940s, interactions between the two species have shown that they will sometimes graze within close proximity of one another, with neither affecting the behavior of the other until about 13 ft (4 m) apart, at which point cattle either altered their direction away from bison or moved aside as the bison approached. Aggressive behavior of bison (usually yearlings) toward cattle was rare, and when it did occur cattle were submissive and driven an average of 13 ft (4 m) away (Van Vuren 1980, 2001). There are no known reports of bison preventing cattle from utilizing vegetation or water sources nor are there reports of bison goring cattle (MFWP 2015a). In central Saskatchewan, ranchers have observed wild Sturgeon River Plains Bison herd in the presence of cattle, but they have had no incidents of bison harassing the cattle and note that the two species appear to tolerate each other (Adams and Dood 2011, MFWP 2015a).

No reports of bison attempting to breed domestic cattle in rangeland conditions are known (MFWP 2015a).

Native pathogens are an integral component of ecosystems and an important factor in natural selection and evolution of wildlife (Ashley et al. 2003, Vander Wal et al. 2014). Disease management is essential to the wellbeing of APR's bison herd and is important to neighboring livestock owners. Disease management of APR's bison falls under the policies and regulations of the MDL and U.S. Department of Agriculture, which include requirements regarding bison imports, reportable diseases, animal disease traceability, and other measures (MDL 2016, USDA 2017). APR also follows IUCN guidelines for managing bison health (Gross et al. 2010). IUCN guidelines are particularly concerned with controlling pathogens that: (1) significantly limit bison population growth directly by reducing survival and (or) reproduction; (2) pose threats to livestock and wildlife populations because this can lead to opposition to bison recovery. These pathogens are generally exotic, having originated from domestic livestock populations, and include bovine tuberculosis, brucellosis, *Mycoplasma bovis*, and malignant catarrhal fever (Gross et al. 2010).

APR has followed and exceeded MDL and USDA requirements for importing, managing and monitoring bison for disease. All bison imported to establish APR's herd came from source herds that have been free of brucellosis and tuberculosis for at least three decades. All imported animals were certified to be free of brucellosis before their release on APR lands. For bison imported to Montana, APR complied with MDL and USDA requirements for bison veterinary inspection, disease testing, vaccination, identification, and quarantine. APR staff consulted with the Montana State Veterinarian and U.S. Department of Agriculture staff veterinarian to ensure that APR's bison import practices satisfied state and federal requirements. The federal veterinarian and his staff attended and reviewed APR's disease testing methods. Local

veterinarians conducted required vaccinations. APR management plans have been reviewed by consulting veterinarians. APR retains a consulting veterinarian.

APR has conducted additional, voluntary disease testing pursuant to a Memorandum of Understanding ("MOU") cooperatively developed by APR and the South Phillips County Rancher Stewardship Alliance in 2005. APR agreed to implement herd health management protocols that exceed MDL and USDA requirements through this "good neighbor" agreement, which respects the rights and interests of private property owners in the vicinity of APR's lands while advancing APR's mission to return bison to the region. During the five-year MOU implementation period, APR conducted routine disease screening of a sample of bison annually through the MDL Diagnostic Laboratory. APR closely monitors its herd and visible signs of herd health by radio-collaring select animals, by on-the-ground surveillance by staff and collaborating institutions, and, as needed, by anesthetizing animals for closer inspection, blood sampling and so on. APR follows standard modeling software to determine the number of bison to sample for proper statistical power for disease screening. If a potentially problematic pathogen is detected, APR will consult with neighbors, agencies and veterinarians and may follow one of three management approaches: 1) a passive approach that primarily involves ongoing monitoring, which may or may not lead to implementing approaches 2 and 3; 2) a control strategy where actions are taken to limit disease prevalence, spread, or risk; 3) eradication, where actions are taken to remove the disease from the population (Gross et al. 2010). APR will notify neighbors and appropriate state and federal agencies about this. Since expiration of the MOU, APR has continued voluntary disease monitoring and periodic testing of 5-20 bison.

All disease screening is done by the Montana State Diagnostic Laboratory in Bozeman and thus any reportable exposures required by the state are thereby reported. To provide a cross-check, APR also sent samples for screening to the Washington Animal Disease Diagnostic Lab (WADDL) in Pullman, which reported the same results as the Montana Lab. APR has never had positive returns for brucellosis or tuberculosis. Since the establishment of the herd APR has seen no active clinical signs of any disease. Herd vigor and reproduction have been excellent.

***Bison and People and the Economy***

Bison are an icon of Great Plains human and natural history, an animal of cultural, aesthetic and spiritual value for millions of people, from Indian tribes of the APR region to people across the North American continent. The 2016 National Bison Legacy Act that designated the American bison as the official mammal of the U.S. codified the bison's special place in the minds of Americans. People are fascinated by and drawn to bison for its strength and striking appearance as North America's largest land mammal. More deeply, the bison's place in the American psyche is evidenced by the myriad stories told, books written and paintings painted about its central role in both human history and the ecology of the Great Plains for thousands of years before and during Euro-American settlement of the Great Plains (Dary 1989, Isenberg

2000, Wallen and White 2015). Visitors to APR and others interested in the reserve are attracted to the vision of thousands of bison thundering across the landscape. This, as much as any biological need, is justification for the goal of 10,000 bison. APR assigns a high priority to meeting these social, cultural and aesthetic benefits and consequently offers diverse opportunities for tourists, hunters, educators, students, artists, scientists and others to experience and benefit from bison conservation.

Bison conservation on APR can economically benefit people and communities in the APR region in multiple ways, including: 1) APR investments in fencing, veterinary care and other infrastructure and services required for bison management; 2) APR investments in facilities and services to host hunters, nature tourists, researchers, students and other groups; 3) personal expenditures by APR staff for good and services; 4) expenditures by hunters, tourists, researchers, students and others for outfitters, lodging, food, gas and other products and services; 5) premium payments to ranchers who support bison conservation under the Wild Sky Beef program; 6) contributions by APR, made possible in part by support for bison conservation, to local community programs.

Northeast Montana ("Missouri River Country"), including the APR region, receives far less spending by non-resident visitors than any other region in the state. In 2015, non-resident visitor expenditures were $113 million, just 28% of the figure ($402 million) for southeast Montana and 9% of the total ($1.229 billion) for Glacier Country (Sage and Nickerson 2017). The CMR Refuge offers the only local example for examining the economic impact of visitors to a wildlife conservation area. Non-local refuge visitors (thus representing new money coming into the area) spent an estimated $20.9 million (2007$) annually in the CMR Refuge's six-county area. This spending was estimated to account for $14.6 million in local output, 204 jobs, and $4.2 million in labor income in the local economy. The secondary or multiplier effects generated an additional $5.9 million in local output, 60 jobs, and $1.6 million in labor income. Accounting for both the direct and secondary effects, spending by non-local visitors generated total economic impacts of $20.5 million (2007$) in local output, 264 jobs and $5.8 million (2007$) in labor income (Koontz et al. 2013).

The CMR Refuge, however, is capturing a small share of wildlife-oriented visitors to Montana and, more specifically, to north-central (Russell Country) and northeast (Missouri River Country) Montana. In 2006, 950,000 residents and non-residents participated in wildlife-associated activities in Montana, generating $1.1 billion, with $231 million from fishing, $311 million from hunting, and $376 million from wildlife-watching activities (USFWS 2008, Koontz et al. 2013). In 2005, Russell Country received 976,140 non-resident visitors who spent $216.8 million; 40% cited wildlife watching as one of the reasons for their visit and 8% visited the CMR refuge. Missouri River Country in 2005 had 283,013 nonresident visitors who spent $32.9 million; 39% cited wildlife watching as important and 14% visited the refuge (Koontz et al. 2013). Given the refuge's modest infrastructure and interpretive materials for visitors this low visitation level by wildlife watchers might be expected. The absence of bison may be another reason.

A recent analysis suggests that the development of APR and its association with the CMR Refuge could generate $12.6 - $38.6 million dollars in additional non-resident expenditures in the region under the current scenario and $13.4 - $56.3 million dollars when APR's vision is fully realized. These non-resident expenditures would result, respectively, in an additional 143 - 469 new jobs (15% - 46% increase) and 163 - 683 new jobs (16% - 67% increase) compared to current conditions (Sage and Nickerson 2017).

Nearby national parks offer another perspective on the potential economic effects of building a 3.5-million-acre prairie reserve with 10,000 bison and the full complement of other wildlife (Table 4). Badlands, Theodore Roosevelt and Wind Cave National Parks are, like APR, mixed-grass prairie ecosystems with similar wildlife. All three have bison. Glacier and Yellowstone are mountain ecosystems, but both are within roughly 200 miles of APR and thus visitors to these parks could readily include APR in a wildlife and wildland oriented tour.

Table 3. Impact of park visitors in 2015 on local gateway economies surrounding five national parks within 350 miles (day's drive) of APR. Source: Cullinane Thomas and Koontz 2016.

| National Park | Visitor expenditures (millions $) | Jobs created | Labor income (millions $) | Value added (millions $) | Economic output (millions $) |
|---|---|---|---|---|---|
| Badlands | 62.2 | 1,000 | 24.4 | 40.1 | 77.5 |
| Theodore Roosevelt | 35.9 | 494 | 13.4 | 21.4 | 38.2 |
| Wind Cave | 60.6 | 1,000 | 25.3 | 41.8 | 80.4 |
| Glacier | 199.0 | 3,500 | 93.5 | 143.4 | 268.6 |
| Yellowstone | 493.6 | 7,700 | 224.8 | 361.9 | 638.6 |

Even in Yellowstone, where there are many high-profile attractions other than bison, bison represent an important component of the visitor experience. One survey found that about 50% of visitors indicated seeing bison was a reason for their trip, and about 5% said they would not have come to Yellowstone if bison had not been present (Duffield et al. 2000a,b). For a crude calculation of the value of bison in terms of visitor expenditures in Yellowstone, a 5% reduction in the number of visitors to Yellowstone in 2015 would have resulted in an estimated $24.7 million less in visitor expenditures in surrounding communities.

As noted above, APR manages its bison for public benefit following principles of the Public Trust Doctrine of the U.S. (Organ et al. 2012).

***Bureau of Land Management (BLM) and Montana Department of Natural Resources (DNRC)***

*i. Bureau of Land Management*: BLM administers 18,000 grazing permits on 155 million acres covering (with the US Forest Service) 15 million animal unit months (AUMs) in the West. APR currently leases 272,717 acres of BLM grazing allotments, which constitute 68% of all the lands APR uses or may use for bison grazing. These allotments provide important bison habitat and it is APR's goal to secure approval for change of use on these allotments from one class of domestic livestock (cattle, sheep, horses, etc.) to another--bison. Management of BLM allotments are primarily regulated by the 1934 Taylor Grazing Act (TGA), the 1976 Federal Land Policy and Management Act (FLPMA) and the 1978 Public Rangelands Improvement Act (PRIA). While the TGA gave preferential privileges for grazing on BLM lands to those "engaged in the livestock business, bona fide occupants or settlers, or owners of water or water rights," FLPMA expanded the recognized uses of public lands by directing BLM to manage its lands "under principles of multiple use and sustained yield" in a manner that protects "scientific, scenic, historical, ecological, environmental, air and atmospheric, water resource, and archeological values." PRIA focused on improving public rangeland conditions. BLM, MDL and the DNRC consider APR's bison and all bison outside Yellowstone National Park and the USFWS National Bison Range as domestic livestock for the purposes of managing grazing leases (BLM 2016, 2017).

BLM permits and leases generally cover a 10-year period and are renewable if BLM determines that the terms and conditions of the expiring permit or lease are being met. BLM, based on NRCS guidance, sets the allowable AUMs for each grazing allotment. BLM and NRCS consider bison and cattle to be equivalent for determining AUMs. Goals for management of BLM grazing allotments in the APR region are established by the BLM HiLine (BLM 2015a) and BLM Lewistown Resource Management Plans (new one currently in draft). All APR leases of BLM allotments are currently in compliance (B.J. Rhodes, BLM, unpublished data, personal communication).

BLM must approve APR's request for a change of use from cattle to bison and from rotational to year-round continuous grazing on APR's BLM grazing allotments. BLM has approved these changes on two of APR's allotments in the past. In 2017 APR requested approval of these changes for most of APR's allotments, which triggered a National Environmental Policy Act (NEPA) review. The Environmental Assessment is expected to be completed in the spring of 2019 and a final decision by BLM 3 - 4 months later.

Any U.S. citizen or validly licensed business can apply for a BLM grazing permit or lease. To do so, one must either buy or control private property (known as "base property") that has been legally recognized by BLM as having preference for the use of public land grazing privileges, or acquire property that has the capability to serve as base property and then apply to BLM to transfer the preference for grazing privileges from an existing base property to the acquired

property (which would become the new “base property”). The first alternative happens when the base property (a private ranch) is sold or leased to a new individual or business; the buyer or lessee then applies to BLM for the use of grazing privileges associated with that property (BLM 2016, 2017). This has thus far been the case for all properties purchased by APR.

APR pays BLM a grazing fee. The federal grazing fee, which applies to public lands managed by the BLM and the U.S. Forest Service in 16 western states, is calculated annually by using a formula originally set by Congress in the Public Rangelands Improvement Act of 1978. Under this formula, as modified and extended by a presidential Executive Order issued in 1986, the grazing fee cannot fall below $1.35 per animal unit month (AUM); also, any fee increase or decrease cannot exceed 25 percent of the previous year’s level. The 2016 grazing fee was $2.11 per AUM and the 2017 fee was $1.87 per AUM (BLM 2017). At these rates the federal government consistently loses money managing federal lands for grazing (Regan 2016).

BLM permittees (BLM grazing allotment permit holders) must make substantial grazing use of their AUMs or risk losing their lease to another operator. Permittees can take temporary non-use for up to 3 consecutive years, however, the BLM could approve another operator to graze the allotment during the permittee’s non-use period. Under Code of Federal Regulations 43 CFR 4130.2(g)(1) another option for BLM leases is “conservation use” for up to 10 years when the authorized official determines the proposed use will promote rangeland resource protection or enhancement of resource values or uses.

Special categories of BLM lands in the region recognize other important ecological and cultural values and the need to manage for them. The 378,000-acre Upper Missouri River Breaks National Monument stretches for 149 miles on both sides of the Missouri River between Fort Benton and the Fred Robinson Bridge. Running through the Monument are the the Upper Missouri National Wild and Scenic River, the Lewis and Clark National Historic Trail, and the Nez Perce National Historic Trail. The region also includes nine BLM Wilderness Study Areas: Cow Creek (34,050 acres), Woodhawk (4,800 acres), Antelope Creek (12,350 acres), Stafford (12,200 acres), Ervin Ridge (5,150 acres), Dog Creek (8,100 acres), Burnt Lodge (14,000 acres), Billy Creek (3,450 acres) and Seven Blackfoot (20,250 acres). In addition, part of Cow Creek is an Area of Critical Environmental Concern (ACEC).

There are 5 standards for rangeland health and 14 guidelines for livestock grazing management of BLM’s HiLine and draft Lewistown management plans. The main headings of those five standards are:

- Standard #1: Uplands are in proper functioning condition.
- Standard #2: Riparian and wetland areas are in proper functioning condition.
- Standard #3: Water quality meets Montana state standards.
- Standard #4: Air quality meets Montana state standards.
- Standard #5: Habitats are provided to maintain healthy, productive and diverse populations of native plant and animal species, including special status species

(federally threatened, endangered, candidate or Montana species of special concern as defined in BLM Manual 6840, Special Status Species Management)

Standard #5 takes on special importance in light of the large number of BLM Special Status and BLM Sensitive Species with ranges in the APR region. BLM Special Status Species Policy (Manual-6840) "gives the State Director the responsibilities of designating the BLM sensitive species and periodically reviewing/updating the list in cooperation with states and with the Natural Heritage Programs. The Sensitive Species designation is used for species requiring special management consideration to promote their conservation and reduce the likelihood and need for future listing under the Endangered Species Act" (August 18, 2014 Instruction Memorandum No. MT-2014-067). The highly endangered black-footed ferret is a BLM Special Status Species. Among BLM Sensitive Species in northeast Montana are the black-tailed prairie dog and swift fox, roughly two dozen bird species, five reptile species, three amphibian species, five fish species, and numerous species of plants.

In addition to addressing the conservation needs of these species, Rangeland Health Standard #5 in the BLM management plans states "...native plant and animal communities will be maintained or improved to ensure the proper functioning of ecological processes and continued productivity and diversity of native plant lifeforms." Thus, as Standard #5 notes, indicators include not only "plant and animal diversity" and "species richness" at all taxonomic levels and measures of "reproductive capability and recovery," but also "connectivity of habitat or presence of corridors [that] prevents habitat fragmentation" and "plant communities in a variety of successional stages [that] are represented across the landscape." Accordingly, BLM HiLine and draft Lewistown livestock grazing management guidelines include:

- Guideline #11: Grazing management should maintain or improve habitat for federally listed threatened, endangered, and sensitive plants and animals.
- Guideline #12: Grazing management should maintain or promote the physical and biological conditions to sustain native populations and communities.
- Guideline #13: Grazing management should give priority to native species.

*ii. Montana Department of Natural Resources and Conservation*: DNRC manages 34,674 acres of the state trust lands leased by APR, which constitute 9% of all lands APR uses or may use for bison grazing. State trust land leases are contracted for 10-year periods. Grazing fees are adjusted year to year based on market conditions. The 2016 rate was $19.57 per AUM and the 2017 rate was $14.01 per AUM. DNRC is involved with the County Conservation Districts. DNRC also oversees the management of rivers and streams for the state (DNRC 2017).

Like BLM, DNRC must approve APR's request for a change of use from cattle to bison and for the removal of some fences. DNRC has approved these changes on two state leases in the past. In 2018 APR requested approval for these changes on most of their state grazing leases. This request will trigger a MEPA (Montana Environmental Protection Act) review, which is expected to be completed in 2019. The results of the MEPA review will inform DNRC's decision regarding approval of APR's request.

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**Appendix 1 - AUMs for each APR management unit using NRCS method and calculated by Environmental Planning and Management Solutions, Inc. (EMPSi)**. Totals may not reflect the sums of deeded, BLM, and State because of rounding. Base data for these calculations can be obtained from EMPSi, APR, BLM, or DNRC.

| | AUMS at Below Normal Precipitation | AUMs at Normal Precipitation | AUMs at Above Normal Precipitation | 2017 AUMs on BLM Permits and State Leases |
|---|---|---|---|---|
| ***Beauchamp Total*** | ***862*** | ***1,231*** | ***1,604*** | N/A |
| | 174 | 248 | 329 | N/A |
| Deeded | 586 | 832 | 1,075 | 282 |
| BLM | 101 | 151 | 199 | 112 |
| State | | | | |
| ***Burnt Lodge Total*** | ***1,771*** | ***2,598*** | ***3,330*** | N/A |
| | 870 | 1,314 | 1,689 | N/A |
| Deeded | 828 | 1,190 | 1,523 | 974 |
| BLM | 72 | 94 | 118 | 83 |
| State | | | | |
| ***C.K. Ridge Total*** | ***155*** | ***236*** | ***303*** | N/A |
| Deeded | 127 | 194 | 248 | N/A |
| BLM | 28 | 42 | 54 | 31 |
| State | N/A | N/A | N/A | N/A |
| ***Dry Fork Total*** | ***5,409*** | ***7,917*** | ***10,549*** | N/A |
| Deeded | 1,633 | 2,394 | 3,133 | N/A |
| BLM | 3,617 | 5,291 | 7,115 | 2,152 |
| State | 158 | 232 | 301 | 133 |
| ***PN Total*** | ***8,445*** | ***11,991*** | ***15,423*** | N/A |
| Deeded | 4,880 | 6,798 | 8,664 | N/A |
| BLM | 2,260 | 3,306 | 4,287 | 2,280 |
| State | 1,304 | 1,886 | 2,472 | 1,638 |
| ***Sun Prairie Total*** | ***4,771*** | ***6,959*** | ***9,023*** | N/A |

| | | | | |
|---|---|---|---|---|
| Deeded<br>BLM<br>State | 1,651<br>3,001<br>120 | 2,393<br>4,395<br>171 | 3,106<br>5,694<br>223 | N/A<br>2,522<br>97 |
| ***Sun Prairie North Total*** | ***3,073*** | ***4,582*** | ***6,128*** | N/A |
| Deeded<br>BLM<br>State | 1,271<br>1,740<br>62 | 1,854<br>2,631<br>98 | 2,332<br>3,628<br>168 | N/A<br>1,243<br>26 |
| ***Timber Creek Total*** | ***23,847*** | ***36,105*** | ***47,041*** | N/A |
| Deeded<br>BLM<br>State | 4,021<br>18,437<br>1,389 | 6,092<br>27,899<br>2,114 | 7,944<br>36,359<br>2,739 | N/A<br>14,169<br>1,339 |
| ***Two Crow Total*** | ***9,137*** | ***12,655*** | ***16,149*** | N/A |
| Deeded<br>BLM<br>State | 1,015<br>7,512<br>610 | 1,426<br>10,364<br>864 | 1,758<br>13,251<br>1,140 | N/A<br>5,461<br>705 |
| ***White Rock Total*** | ***7,939*** | ***11,474*** | ***14,877*** | N/A |
| Deeded<br>BLM<br>State | 3,593<br>3,649<br>697 | 4,976<br>5,476<br>1,023 | 6,355<br>7,154<br>1,369 | N/A<br>2,779<br>307 |
| ***Total All Property Units*** | ***65,409*** | ***95,748*** | ***124,427*** | N/A |
| Deeded<br>BLM<br>State | 19,235<br>41,658<br>4,513 | 27,689<br>61,416<br>6,633 | 35,558<br>80,140<br>8,729 | N/A<br>31,893<br>4,440 |