# Bison Literature Review

Ben Baldwin and Kody Menghini

The purpose of this document is to compare the biology, ecology and basic behavior of cattle and bison for a management context. The literature related to bison is extensive and broad in scope covering the full continuum of domestication. The information incorporated in this review is focused on bison in more or less "wild" or free-ranging situations i.e.., not bison in close confinement or commercial production. While the scientific literature provides a solid basis for much of the basic biology and ecology, there is a wealth of information related to management implications and guidelines that is not captured. Much of the current information related to bison management, behavior (especially social organization) and practical knowledge is available through local experts, current research that has yet to be published, or popular literature. These sources, while harder to find and usually more localized in scope, provide crucial information pertaining to bison management.

## Biology

### Diet Composition

Bison evolutional history provides the basis for many of the differences between bison and cattle. Bison due to their evolution in North America ecosystems are better adapted than introduced cattle, especially in grass dominated systems such as prairies. Many of these areas historically had relatively low quality forage. Bison are capable of more efficient digestion of low-quality forage then cattle (Peden et al. 1973; Plumb and Dodd 1993). Peden et al. (1973) also found that bison could consume greater quantities of low protein and poor quality forage then cattle.

Bison and cattle have significant dietary overlap, but there are slight differences as well. Bison primarily feed on grass, though shifting between warm and cool season grasses seasonally (Plumb and Dodd 1993). These authors also found that forbs and browse combined are less then 10% of bison diets. Cattle have less seasonal variation in grasses then bison, but forbs and browse compose 15% and 10% of cattle diets respectively (Plumb and Dodd 1993). Bison do consume more C4 grasses then cattle (Plumb and Dodd 1993) and digest warm-season grasses better then cattle do in winter (Peden et al. 1973).

Within bison there are difference in diet quality and quantity between sexes and age groups. Mature bulls tend to choose sites that are low in nutrition, while cows choose sites with high nutritional values (Post et al. 2001). Bulls have adapted to lower energy diets by consuming greater amounts of forage and possibly being able to extract more energy from equal amounts of forage as cows, calves, and yearlings (Post et al. 2001). Post et al. (2001) also found that calves have the highest quality diet because they graze and nurse, and yearlings have similar diets to cows.

### Disease

There are three main diseases that are of concern in bison; anthrax, bovine tuberculosis, and bovine brucellosis (Boyd 2003). Disease transmission from wild ungulates, such as bison, to domestic livestock, such as cattle, is a very contentious issue involving many federal and state

laws that attempt to eliminate contact between different species. Specific information for each disease is listed below.

*Anthrax*
Anthrax is an infectious bacterial disease caused by *Bacillus anthracis* (Dragon and Rennie 1995; Boyd 2003). Anthrax occurs in the form of spores. Once in an area, spores can persist in the soil for decades causing sporadic outbreaks (Dragon and Rennie 1995; Dragon et al. 1999). Activities that break up soil, such as wallowing by bison, can disperse spores into the air and infect bison. When an individual is infected with anthrax they will appear gaunt, depressed, and indifferent to activity around them (Dragon et al. 1999). Anthrax affects a significantly higher number of sexually mature bulls then other bison ages or sexes (Dragon et al. 1999)

*Bovine Tuberculosis*
Bovine Tuberculosis is a chronic infectious disease caused by bacterium *Mycobaterium bovis* (Tessaro 1989; Boyd 2003). Bison did not come into contact with this disease until they received it from cattle (Tessaro et al. 1990, Boyd 2003), though both cattle and bison are primary hosts (Boyd 2003). Bovine tuberculosis can cause a reduction in fertility, weakness, and fatality (FEARO 1990; Boyd 2003). Transmission can occur from inhalation or ingestion (Tessaro et al. 1990; Boyd 2003).

*Bovine Brucellosis*
Bovine Brucellosis is caused by the bacterium *Brucella abortus* (Tessaro 1989; Tessaro 1992; Boyd 2003). This disease was introduced to North America in the 1500s (Meagher and Meyer 1994; Aguirre and Starkey 1994; Boyd 2003), likely being transmitted from cattle (Meagher and Meyer 1994). As with bovine tuberculosis, host of this disease are bovids, including both cattle and bison (Tessaro 1992; Boyd 2003). Transmission occurs through oral contact with aborted fetuses, contaminated placentas, and uterine discharges (Reynolds et al. 1982; Tessaro 1989; Boyd 2003).

## Ecology

### Grazing

Bison and cattle have a high degree of similarity in modifying the composition and diversity of tallgrass prairie, though difference in foraging behavior and physical impacts between the herbivores cause divergent trends overtime in some plant species (Towne et al. 2005). The ability to affect selected plant species is likely do to variation in dietary, physiological, and behavioral attributes of bison and cattle (Matlack et al. 2001). Fortin et al (2002) found that bison dietary decisions could largely be explained by rules of energy maximizations, e.g. bison prefer rapid energy acquisition, even at the expense of long-terms gains. Other differences between bison and cattle are grazing locations. Bison strongly prefer open grassland areas whereas cattle use wooded and open habitats more opportunistically (Hartnett et al. 1997) Bison develop and utilize grazing patches (Catchpole 1996; Knapp et al. 1999) and extensive grazing lawns (McNaughton 1984; Knapp et al. 1999). This results in more heterogeneous grazed bison pastures with localized areas of heavy use. There can also be differences in topographic location of grazing by bison and cattle. Cattle selectively graze in swales or shallow depressions, where soil moisture is higher than in surrounding vegetation (Peden et al. 1973) while bison select areas based on other factors.

Bison also occur in mountainous areas, such as the Henry Mountains in southern Utah. Van Vuren (2001) found that bison used steeper slopes, higher elevation, and traveled farther from water then cattle did in mountainous areas. Slope and distance from water, especially vertical distance, are the most important variables that influence cattle distribution while forage availability is most important in determining bison distribution (Van Vuren 2001)

At the grazing patch scale, cattle are more selective foragers then bison (Peden et al. 1973; Plumb and Dodd 1993). Plumb and Dodd (1993) also found that cattle selected for patches with high quality forbs and browse and bison selected against these patches in tallgrass prairie. Bison tend to prefer patches with low plant diversity and forage quality. Bison are able to use the available forage (Peden et al. 1973) in the lower quality sites, thus allowing other plant species to increase, creating higher plant diversity (Knapp et al. 1999). Patch diversity can also be affected by dung and urine composition and trampling (Knapp et al. 1999), but this is likely to occur with both bison and cattle. Forage intake rate and grazing density may be much greater for cattle than bison, even with similar densities (Towne et al. 2005).

Bison and cattle differ in the way they bite vegetation while foraging. Cattle tend to use their tongue on a horizontal plane to vegetation (Hudson and Frank 1987; Matlack 2001) while bison use their lips, allowing them to graze closer to the ground, resulting in closely chopped patches (Hartnett et al. 1997; Matlack 2001). The difference in bite pattern can create a more evenly and closely grazed bison area sometimes refereed to as "lawns".

It should be cautioned that although there are notable differences between cattle and bison gazing, these differences may not be directly attributed to inherent differences in the species but rather the grazing management practices. Plant communities are relatively similar between bison and cattle pastures through time, suggesting that the management of the herbivores may play a larger role on vegetation impacts than the differences between species (Towne et al. 2005). Towne et al. (2005) also found a larger difference in plant community diversity between grazed and ungrazed pastures then between cattle and bison grazed pastures. Thus indicating that the presence or absence of grazing was more important to plant community that the particular species of the herbivore. Another important factor in considering bison or cattle to graze an area is scale. The degree that bison and cattle are ecologically analogous is scale dependent and the choice to use cattle or bison to graze should match scale-dependent management goals (Plumb and Dodd 1993).

**Fire**

North American prairies developed under the influence of fire and bison (Axelrod 1985; Coppedge and Shaw 1998). The literature indicates that the combination of fire and bison grazing created the prairie ecosystem; not just fire or bison acting alone. Fire may be an important determinant of the pattern of large herbivore grazing activity, which is often spatially and temporally heterogeneous (Coppock and Delting 1986; Shaw and Carter 1990; and Vinton et al. 1993). Coppedge and Shaw (1998) stated that the timing of burning a prairie, based on the active versus dormant season, and the affects on vegetation and herbivore response is not well understood. The author's study did show that bison preferred areas burned in the summer to areas burned in the fall and spring (Coppedge and Shaw 1998). Bison also choose burned areas in the tallgrass prairie that have high levels of exotic,

cool season grasses, usually *Bromus spp*., in the autumn and winter (Vinton et al. 1993; Coppedge and Shaw 1998).

Grazing can also affect fire and subsequently how the fire will affect vegetation. Towne et al. (2005) found differences in cattle and bison grazing and these differences influenced the burn pattern and fire effect on some plants. Because Bison tend to graze more heterogeneous then cattle, cattle grazed pastures tend to have a higher and more homogeneous fuel load. Due to these factors cattle grazed pastures tend to burn more completely then bison grazed pastures creating a positive feedback cycle for fire tolerant species and unfavorable conditions for fire sensitive species (Towne et al. 2005).

**Area Required**

Bison are a highly mobile animal and tend to use large expanses of land. Meagher (1989) reported bison traveled 32 kilometers in a single day. Coppedge and Shaw (1998) found in Kansas that bison traversed the Nature Conservancy's 15,000 hectare Tallgrass Prairie Preserve in only a few hours. Area requirements for bison vary based on the quality and quantity of available forage and habitat. Related to the area requirements are the athletic ability of bison (e.g., bursts of speed, high endurance and leaping ability) and the seemingly blatant disregard of fencing or barriers. Bison move to find optimal habitat and depending on the season this could be related to forage, water, safety, or reproduction.

**Snow and Thermoregulation**

Bison exhibit adaptations to winter survival that are superior to cattle (Plumb and Dodd 1993; Van Vuren 2001). Generally, bison are thought to be well adapted to snow being native to environments which receive large amounts of annual snow, such as Yellowstone National Park and areas in Canada. Several studies indicate that bison have adapted to and can live in heavy snow conditions. These adaptations include the ability to utilize lower quality forage, dig though deep snow to forage and utilize snow as a water source. Groups of bison have been observed to regularly foraging in snow depths of 600 millimeters (Houston 1982; Meagher 1989). Bison adjust and adapt to conditions in order to save energy, physiologically lower metabolism rates and behaviorally. Fortin et al. (2003) found that female bison reduced daily displacement from 2 kilometers to 1.3 kilometers during winter and Telfer and Kelsall (1982) stated that bison make and use trails and cows have a lower foot loading than bulls and can walk on top of wind-packed snow.

Thermoregulation is a vital adaptation for bison to survive in cold weather. Bison calves reduce their metabolic rate when extreme cold (-30ºC) more than cattle, thus reducing the need for food and energy (Christopherson et al. 1978; Plumb and Dodd 1993). Thermoregulation through habitat selection has shown to be a successful behavior that allows bison to cope with extreme temperatures (Belovsky and Slade 1986; Plumb and Dodd 1993).

**Behavior**

Specific comments concerning bison behavior are challenging to make due to the large degree of difference (e.g., the size of the herds, sex ratios, habitats, degree of domestication) in existing bison herds and under the current management. Generally, bison exhibit strong social structuring while cattle social structure is much weaker. Bison are highly gregarious with a distribution that is male-biased and social groups that are often composed of closely

related philopatric females. There tends to be strong matriarchal influences on the social order with dominate cows playing a primary role in herd movements. Social relationships between mothers and daughters tend to persist for multiple years. Bison travel and graze in herds which include dominant bulls. Cow-calf groups and bull groups can occur in the same area in the spring and summer without conflict (Post et al. 2001). Non-dominant bulls usually travel alone or in small groups distant from the rest of the herd.

Bison have polygamous mating habits in which a dominant bull will maintain a harem of females. Dominance is asserted over other males not over a particular territory or site. During the mating season or rut, bison behavior changes significantly. Herds increase in size and bulls become more aggressive. Bulls engage in disputes to determine social hierarchy and breeding preference. The ratio of bulls to cows is an important consideration for predictors of bison behavior. Non-dominant bulls or "bachelor" herds will repeatedly fight with the dominate bull and if unsuccessful have been known to travel large distances to find mates.

Bison spend less time grazing than cattle and more time in non-feeding activities (Plumb and Dodd 1993). These non-feeding activities, particularly those unique to bison such as wallowing and horning (i.e., rubbing on trees and other objects), are important considerations and pose significant potential to damage habitat especially when confined to small areas or in the same area over long periods of time. Wallowing creates unique disturbances that have both negative and positive aspects. They can contribute to an increase in species richness, allowing for annuals and early successional plants to establish due to moisture accumulation (Towne et al. 2005). Wallows also can cause site degradation due to physical disturbance and prevent plant establishment. It has also been suggested that bison influence and limit the distribution of woody vegetation by horning and rubbing (England and DeVos 1969). Reports of bison damage by horning and rubbing on man-made structures, such as utility poles, has occurred (Coppedge and Shaw 1997).

**Management Considerations**

Questions related to appropriateness of bison should place greater importance on management strategies and objectives rather than ecological equivalency between species of herbivores (Plumb and Dodd 1993, Towne et al. 2005, Knapp et al. 1999). Existing paradigms related to appropriate herbivory levels and species, and the historic herbivory and associated vegetative response often overshadows important social constraints and considerations. Many of the historic conditions related to bison have changed, most notably the degree of domestication, available range, and vegetational composition. As additional management constraints are added the appropriateness of bison changes as does the predictability of existing scientific information. Plumb and Dodd (1993) capture the essence of this concept in figure 1. The suitability of cattle and bison are compared for a grassland management area under four different management parameters. These general trends can be developed to include other site specific considerations. For example, as management area size decrease, direct management of the bison herd will need to increase related to culling to controlling male-female ratios, overall numbers and aggressive animals. Other possible parameters include: degree of domestication, public safety, potential for disease transmission, adjacent land ownership, sensitive structures (e.g. witness trees, historic buildings or markers), fencing, surrounding habitat or available forage, herd size, sensitive or endangered species, etc.

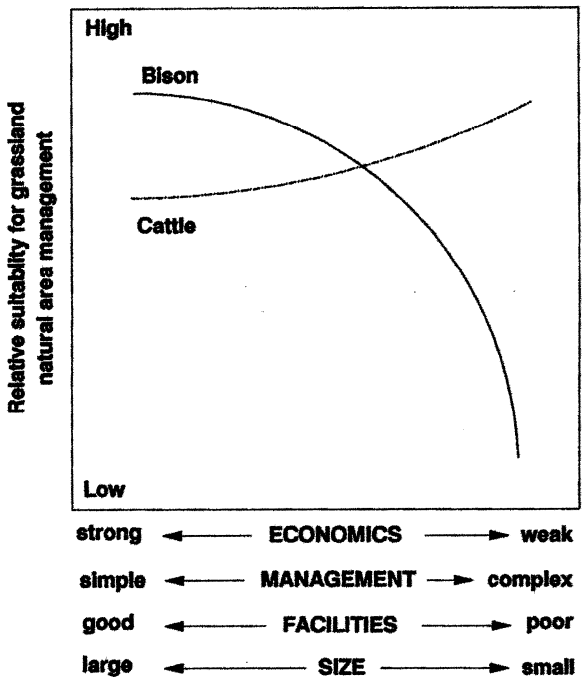


**Figure 1: Simplified depiction of the suitability of bison and/or cattle for grassland natural area management under several programmatic considerations. (Plumb and Dodd 1993)**

## Literature Cited

Aguirre, A. A.. and E. E. Starkey. 1994. Wildlife disease in the U.S. national parks: historical and coevolutionary perspectives. *Conservation Biology* 8: 654-661.

Axelrod, D. I. 1985. Rise of the grassland biome, central North America. *Botanical Review* 51: 163-202.

Belovsky, G. E. and J. B. Slade. 1986. Time budgets of grasslands herbivores: body size similarities. *Oecologia* 70: 53-62.

Boyd, D. P. 2003. Conservation of North American Bison: Status and Recommendations. Masters Thesis, University of Calgary.

Catchpole F. B. 1996. The dynamics of bison (*Bos bison*) grazing patches in tallgrass prairie. Masters thesis. Kansas State University, Manhattan, KS.

Christopherson, R.J., R. J. Hudson, and R. J. Richmond. 1978. Comparative winter bioenergetics of American bison, yak, Scottish highland and Hereford calves. *Acta Theriologica* 23: 49-54.

Collins, S. L., A. K. Knapp, J. M. Briggs, J. M. Blair, E. M. Steinauer. 1998. Modualtion of diversity by grazing and mowing in native tallgrass prairie. *Science* 280: 745-747.

Coppedge, B. R. and J. H. Shaw. 1997. Effects of horning and rubbing by bison (*Bison bison*) on woody vegetation in a tallgrass prairie landscape. *American Midland Naturalist* 138: 189-196.

Coppedge, B. R. and J. H. Shaw. 1998. Bison grazing patterns on seasonally burned tallgrass prairie. *Journal of Range Management* 51: 258-264.

Coppock, D. L. and J. K. Delting. 1986. Alteration of bison and black-tailed prairie dog grazing interaction by prescribed burning. *Journal Wildlife Management* 50: 452-455.

Dragon, D. C., B. T. Elkin, J.S. Nishi, and T. R. Ellsworth. 1999. A review of anthrax in Canada and implications for research on the disease in northern bison. *Journal of Applied Microbiology* 87: 208-213.

Dragon, D.C. and R. P. Rennie. 1995. The ecology of anthrax spores: tough but not invincible. *Canadian Veterinary Journal* 36: 295-301.

England, R. E. and A. DeVos. 1969. Influence of animals on pristine conditions on the Canadian grasslands. *Journal of Range Management* 22: 87-94.

Federal Environmental Assessment Review Panel (FEARO). 1990. Northern diseased bison. Report No. 35 of the Environmental Assessment Panel. August 1990. Federal Environmental Assessment Review Office, Hull, PQ.

Fortin, D., J. M. Fryxell, L. O'Brodovich, and D. Frandsen. 2003. Foraging ecology of bison at the landscape and plant community levels: the applicability of energy maximization principles. *Oecologia* 134: 219-227.

Hartnett, D.C., K. R. Hickman, and L. E. Fischer Walter. 1996. Effects of bison grazing, fire, and topography on floristic diversity in tallgrass prairie. *Journal of Range Management* 49: 413-420.

Hartnett, D. C., A. A. Steuter, and K. R. Hickman. 1997. Comparative ecology of native and introduced ungulates, p. 72-101. In; F. Knopf and F. Sampson (eds). Ecology and conservation of Great Plains vertebrates. Springer, New York.

Houston, D. B. 1982. The northern Yellowstone elk, ecology, and management. Macmillan Publication. Co., New York, 474 pp.

Hudson, R. J. and S. Frank. 1987. Foraging ecology of bison in aspen boreal habitats. *Journal of Range Management* 40: 71-75.

Knapp, A. K., J. M. Blair, J. M. Briggs. S. L. Collins, D. C. Hartnett. L. C. Johnson, and E. G. Towne. 1999. The keystone role of bison in North America tallgrass prairie. *BioScience* 49: 39-50.

Lott, D. F. and J. C. Galland. 1987. Body mass as a factor influencing dominance status in American bison cows. *Journal of Mammalogy* 68: 683-685.

Matlack, R. S., D. W. Kaufman, and G. A. Kaufman. 2001. Influence of grazing by bison and cattle on deer mice in burned tallgrass prairie. *American Midland Naturalist* 146: 361-368.

McNaughton, S. J. 1984. Grazing lawns: animals in herds, plant form, and coevolution. *The American Naturalist* 124: 863-886.

Meagher, M. 1989. Range expansion by bison of Yellowstone National Park. *Journal of Mammalogy* 70: 670-675.

Meagher, M. and M. E. Meyer. 1994. On the origin of brucellosis in bison of Yellowstone National Park: a review. *Conservation Biology* 8: 645-653.

Peden, D. G., G. M. Van Dyne, R. W. Rice, and R. M. Hansen. 1973. The trophic ecology of *Bison bison* L. on shortgrass plains. *Journal of Applied Ecology*11: 489-498.

Plumb, G. E. and J. L. Dodd. 1993. Foraging ecology of bison and cattle on a mixed prairie; implications for natural area management. *Ecological Applications* 3: 631-643.

Post, D. M., T. S. Armbrust, E. A. Horne, and J. R. Goheen. 2001. Sexual segregation results in differences in content and quality of bison (*Bos bison*) diets. *Journal of Mammalogy* 82: 407-413.

Reynolds, H. W., R. D. Glaholt, and A. W. L. Hawley. 1982. Bison. Pages 972-1007 in Chapman, J. A. and G. A. Feldhamer, eds. Wild mammals of North America: biology, management, and economics. The John Hopkins University Press, Baltimore and London.

Rutberg, A. T. 1983. Factors influencing dominance status in American bison cows (*Bison bison*). *Z. Tierpsychol,* 63: 206-212.

Samson, F. and F. Knopf. 1994. Prairie conservation in North America. *BioScience* 44: 418-421.

Shaw, J. H. and T. S. Carter. 1990. Bison movements in relation to fire and seasonality. *Wildlife Society Bulletin* 18: 426-430.

Telfer, E. S. and J. P. Kelsall. 1984. Adaptation of some large North American mammals for survival in snow. *Ecology* 65: 1828-1834.

Tessaro, S. V. 1989. Review of the disease, parasites and miscellaneous pathological conditions of North American bison. *Canadian Veterinary Journal* 30:416-422.

Tessaro, S. V. 1992. Bovine tuberculosis and brucellosis in animals, including man. Pages 207-224 in Foster, J., D. Harrison and I. S. MacLaren, eds. Buffalo. The University of Alberta Press, Edmonton, Alberta.

Tessaro, S. V., L. B. Forbes, and C. Turcotte. 1990. A survey of brucellosis and tuberculosis in bison in and around Wood Buffalo National Park, Canada. *Canadian Veterinary Journal* 31: 174-180.

Towne, E.G., D. C. Hartnett, and R. C. Cochran. 2005. Vegetation trends in tallgrass prairie from bison and cattle grazing. *Ecological Applications* 15: 1550-1559.

Van Vuren, D. H. 2001. Spatial relations of American bison (*Bison bison)* and domestic cattle in a montane environment. *Animal Biodiversity and Conservation* 24.1 117-124

Vinton, M. A., D. C. Hartnett, E. J. Finck, and J. M. Briggs. 1993. Interactive effects of fire, bison (*Bison bison*) grazing and plant community composition in tallgrass prairie. *American Midland Naturalist* 129: 10-18.