Reintroduction of Bison (*Bison bison*) on Reservations in South Dakota: Four Case Studies

BY

Trudy M. Ecoffey

A dissertation in partial fulfillment of the requirements for the

Doctor of Philosophy

Major in Biological Sciences

South Dakota State University

2009

Reintroduction of Bison (*Bison bison*) on Reservations in South Dakota: Four Case Studies

This dissertation is approved as a creditable and independent investigation by a candidate for the Doctor of Philosophy degree and is acceptable for meeting the dissertation requirements for this degree. Acceptance of this dissertation does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

_____
Dr. Timothy J. Nichols
Dissertation Co-Advisor

_____
Dr. Diane H. Rickerl
Dissertation Co-Advisor

_____
Dr. John Ruffolo
Program Coordinator

Acknowledgements

I would first like to thank the Kellogg Foundation and the South Dakota State University Prairie PhD program for providing me this opportunity to complete this study and dissertation. This includes all of those instructors who were willing to make class work available through distance education and other means for the PhD and MS students in the program so that we could complete our studies without having to leave our families, communities and jobs to obtain a higher degree.

My deepest gratitude to the four case study individuals that allowed me to interview them and to study and learn from their perspectives entities. Thank you for allowing me the opportunity to complete this research. Your knowledge, dedication and love for the Pte Oyate (Buffalo Nation) is apparent; future generations of Lakota people will include you in their songs and prayers for the foresight and inspiration that you provided for a multiple of people both Lakota and non-Lakota people. May Tunkashila bless you and your families for all you have done to bring bison back to the Lakota People.

My sincere thank you to my graduate committee for their willingness to step out with me on this venture and have enough faith in me to complete this project: Dr. Arvid Boe, Dr. Kent Jensen, and Dr. Teresa Hall. Also, thank you to Pat Wieland for all her data entry, great talks in the lab and tromping out in the field with Diane and I when it was hot, cold, windy or rainy. Double thanks and gratitude to Dr. Diane Rickerl and Dr. Timothy Nichols for not only working so closely with me on this project, but for developing the Prairie PhD program so that I could complete my PhD and dissertation.

Great appreciation to you Diane for engaging me in this “fifth child” called research with the bison. It has been a great pleasure to work with you all.

Also, a thank you to those teachers in my past that inspired me in the sciences and my professional career. You provided me the educational background to complete this: Mr. Rex Robison; Mr. Mark Peyton; and Mr. Bud Stolzenburg,

A big thank you to my sisters Lori Ann and Heidi, and sister-in-laws Renee and Connie for watching my children while I studied and went to classes. To my brother-in-law Allen for taking care of things while we were gone for one reason or another; and to my brother Henry for getting well and continuing to stay well. You guys are awesome!

A big thank you, hugs and kisses to my children, Echo Dawn, Jade, Jules and to my husband Lee. You guys are the wind beneath my wings, you inspire me to do better every day and for you I wanted to complete this so that I can build a better life for us with the knowledge I have gained through this process. You have sacrificed a lot for me to complete this. Thanks for hanging in there with me!

Last but not least I want to thank my mom, Marie Miller-Mess for her undying support through the years of schooling. You’re the best!

I dedicate this dissertation in the memory of my father, Edward H. Miller, who taught me respect for all living things and to the Glory of the Almighty Father through Jesus Christ Our Risen Lord and to the Pte Oyate (Buffalo Nation), may you always be with us!

Abstract

Reintroduction of Bison (*Bison bison*) on Reservations in South Dakota:

Four Case Studies

Trudy M. Ecoffey

2009

This research explored and documented issues of sustainability associated with the reintroduction of bison in four different bison herds on Reservations in South Dakota. The four herds were managed by: a tribal family cooperative, an individual tribal member, a tribal university and a tribal fish and wildlife agency. The objectives were to identify management practices associated with the sustainability of bison introduction by American Indians; to explore the role of American Indian culture in the management of bison for sustainability; and to investigate rangeland criteria that could be used to measure sustainability of bison reintroduced by American Indians.

This project used a holistic, descriptive approach including interviews, coding, and analysis to build themes among the four case studies. The four case study interviews focused on overall management: general practices; environmental issues; economic concerns and cultural issues associated with tribal bison reintroduction. The case study also included rangeland data collection and analysis to determine both soil and plant quality. Soil quality criteria included organic matter, aggregate stability, water content, and chemical analyses. Plant criteria included measures of crude protein, acid detergent fiber, neutral detergent fiber, dry matter production and a species inventory. Each site

had replicated plots in shoulder-, mid-, and toe-slope positions with the mid-slope positions having grazed and ungrazed treatments.

Common themes that emerged from the interviews included: a hands-off management style; concern for the health and interactions of the land, animals and people; and a de-emphasis of the importance of economics. All four managers acknowledged the importance of cultural traditions and three expressed a deep cultural and spiritual connection to the bison. Results from the soil and plant quality analysis indicated that rangeland conditions were equal to or better than those measured on other grasslands in South Dakota or reported in the literature for mixed-grass prairie. Soil chemical and physical properties supported a diverse plant population with adequate levels of nutrition for bison.

. The Lakota philosophy of Mitakuye Oyasin, “all my relatives”, reflects the Native understanding of connectedness of all aspects of life. This holistic understanding was present in the approach of all four bison managers. Integrating the qualitative and quantitative data from these case studies offers valuable insight into the challenges, successes and unique perspectives of a diverse group of herd managers and contemporary Native leaders of tribal bison reintroduction.

Table of Contents

List of Tables

Chapter 1. Introduction and Background

Introduction

Many contemporary American Indian tribes are working to 'bring back' or re-introduce buffalo on reservations across North America. This study presents case study analyses, including both qualitative interview data and quantitative ecological data, profiling four distinct approaches to bison reintroduction. These approaches, all of which take place among Lakota people on reservations in South Dakota, include herds owned and managed by 1) Tribal Community Bison managed by a tribal family cooperative; 2) Tiospaye Bison managed by an individual tribal member; 3) Tribal University Bison managed by a tribal university; and 4) Tribal Bison managed by a tribal fish and wildlife agency. Interview and rangeland data will be analyzed and discussed to enhance the understanding of similarities, differences, impacts, advantages and challenges presented by each approach.

Background

Historically, bison played a central role in many Great Plains Indian tribal cultures. Bison were integral to the Lakota people's sustenance, economy, arts, and spirituality. Not coincidentally, the once prosperous Lakota culture declined following The Great Slaughter of buffalo on the Plains in the 1870s. In more recent years, as American Indian tribes have asserted their sovereignty, begun language and cultural revitalization programs, and founded their own higher education institutions, bison production has increased. Several models for bison ownership among Native Americans have emerged, including those in our studies.

As Native people have begun to become involved with bison again, they have found little research to guide their work, and even less that respected their worldview and considered their 'sacred relationship' with the 'buffalo nation'. During the late 1990's, a group of tribal college faculty and staff from institutions in North and South Dakota, formed a consortium called the Northern Plains Bison Education Network (NPBEN) aimed at strengthening tribal college research and education programs around buffalo. NPBEN developed an *indigenous homeland philosophy* which states, in part:

> …(the network) believe(s) sacred cultural connections exist between and among the bison, the land, and the people indigenous to the Northern Great Plains. Because of these…NPBEN…embraces and promotes the understandings that… a) bison are to be respected as sacred animals and relatives important to the well-being of prairie ecosystems and people, in particular, tribal nations and native people; b) bison will be sustained in a natural, compatible environment with minimal interference, restrictions, and constraints; c) human interaction with bison will be represented in a caretaker role that may be different from the traditional Euro-American or Western agriculture management model; and d) the caretaker role for bison will entail humane, low stress handling methods and resources (USDA CREES, 2003).

How, to what extent, and in what ways do such beliefs pervade the diversity of contemporary Native American bison production management practices? What impact does management approaches based on such principles have on biological factors relating to the larger prairie ecosystem? This research explores these questions and presents baseline data for understanding the nexus of culture, science, and management of bison among contemporary tribal people.

Chapter 2. Literature Review

This review of the literature is organized into four sections that explore 1) bison history and culture, 2) re-introduction of bison, 3) ecological assessments and impacts and 4) Native American bison management. The goal is to explore what is known on these topics and thus set the stage for future exploration of the research questions.

Bison History and Culture

Authors have written about the North American bison and the relationship they shared with the indigenous people of the continent for centuries. Some of the early writings include the Spanish, who initially described bison as the "shaggy-maned mammal". Great herds of bison were noticed by the Cabeza de Vaca and members of the Spanish expeditions in the 1530's. Europeans later called them "buffalo" after the Asian and African wild oxen. They may have been named after the Latin word, 'bos' or 'head of cattle', from which the French word 'boeff', and the English word, 'beef' originate (Flores, 1991).

The Lewis and Clark expedition also encountered bison on their journey through the Louisiana Purchase and talked about large herds of bison in their journal entries:

> Derected my Servent York with me to kill a Buffalow near the boat from a number. Scattered in the plains, I saw at one view near the river at least 500 Buffalow, those animals have been in view all day feeding in the Plains, (Lewis and Clark Journal, Journal Excerpts, 1803-1806; Abridged Ed, 2003).

Lewis had seen great "gangues" of bison on more than one occasion--an estimated 3,000 near Oacoma, South Dakota, in September of 1804, and 10,000 at the Great Falls of the Missouri on July 1, 1805.

> South of the White River, near today's Chamberlain, South Dakota, on August 29, 1806, he beheld an awesome sight (Lewis and Clark Journal, Journal Excerpts 1803 -1806; Abridged Ed. 2003).

Later that same century, George Catlin, a famous writer and painter who traveled North America documenting Indian tribes of the west in the 1830s and 1840s, reported in 1841:

> These animals are, truly speaking, gregarious, but not migratory—they graze in immense and almost incredible numbers at times, and roam about and over vast tracts of country, from East to West, and from West to East, as often as from North to South … The almost countless herds of these animals that are sometimes met with on these prairies, have been often spoken of by other writers, and may yet be seen by any traveler who will take the pains to visit these regions. (Catlin, 1841, Letter no. 31)

Despite sometimes conflicting origin stories, scholars agree – tribal people followed large herds of bison and other animals throughout North America for centuries before European explorers arrived on the continent. The relationship between bison and Native American people has a known record going back to the Holecene age or about 10,000 years ago (Geist, 1996). No one is certain how many buffalo were on the continent before Anglo settlement. However, accounts of early explorers estimated the bison population in the hundreds of millions, while later scientists approximated the population between 15-20 million (Cushman and Jones, 1988), 28 million (Flores, 1991), 60 million (Hornday, 1890) and 30 million to 60 million (McHugh 1972). Callenbach (1996), Danz (1977) and Haines (1970) argue that bison herds roamed most of what now comprises the continental US, along with parts of northern Mexico and wide areas of Canada and Alaska. Larger herds of plains bison (*Bison bison*) more than likely lived in the Great Plains region, with smaller herds of wood bison (*Bison athabascae*) roaming in

what is now the eastern US and Canada, and possibly, a sub-species of mountain bison roamed the Rocky Mountains (Dary, 1974; Mails, 1995).

Tribal people of North America, particularly in the Great Plains region, evolved parallel to the bison. An integrated bond was formed between Native Americans and bison because of the people's dependency on the animals for food and other essential items (Danz, 1997). "No man living here today has the wealth we had before the destruction of the buffalo," according to Charlie Ereaux, tribal member from the Fort Belknap Reservation, "They were our food, our house, our tools, our pharmacy, our spiritual dignity. They were our freedom." (Chadwick, 1998 pp. 28).

The relationship intensified between Native Americans and bison with the introduction of the horse to North America in the mid-1600 by the Spaniards. Native Americans became master horsemen. Horses provided improved transportation, easier hunting, and led, ultimately, to a more nomadic lifestyle which allowed tribes to follow large buffalo herds for much of the year (McHugh, 1972). This led to great cultural, spiritual and economic value being placed on the bison by Great Plains Indians and many other tribes across the continent of North America (Danz, 1997).

Mahpiya luta (Red Cloud), chief of the Oglala Lakota, commented to U.S. officials during his trip to Washington in the mid-1800s:

> We told them that the supernatural powers Taku Wakan, given to the Lakota, the buffalo for food and clothing. We told them that where the buffalo ranged, that was our country. We told them that the country of the buffalo was the country of the Lakota. We told them that the buffalo must have their country and the Lakota must have the buffalo. (Walker, 1991 pp.138-139).

Mails (1995) charted more than 160 non-edible food items made from the different parts of the buffalo. Intertribal Bison Cooperative (ITBC), an organization developed in 1992 to restore bison to Native lands, identifies more than 160 items obtained from bison that were used for everyday life by Native Americans. For example, weapons and tools were made from bison bones; hides provided bedding, tipis, cases, clothing and drums; horns provided cups, ladles, spoons and powder horns (ITBC, 2007). ITBC describes bison as the 'Native American's grocery store'. Indeed, bison formed the foundation of the indigenous economy of the Great Plains.

Major portions of the Plains Indians' lifestyle revolved around the buffalo. Hunting practices and the preparation for the kill were etched into the people's spiritual practices (McHugh, 1972; Danz, 1997). When the buffalo moved from winter ranges to summer ranges, Native people also moved to be in close proximity to them.

Bison not only provided food and shelter, the animal became a spiritual and cultural focal point for Plains Indians (Mails, 1995; Danz, 1997). Buffalo were central to many indigenous songs, dances, stories and ceremonies of the region. The Lakota Sundance religious ceremony revolved around the bison theme and depicted the people's deep respect for bison. Tribal holy men sought buffalo through visions that could inspire medicinal practices. The use of skulls and other parts of the bison became a ritualistic practice (Mails, 1995). The White Buffalo Calf Woman's story from the Lakota is one of the deep spiritual stories that evolved. This story describes how a woman in the form of a buffalo came with a sacred pipe and showed the Lakota how to live properly (Pickering, 1997; Lame Deer and Erodes, 1972).

As Anglo settlements moved westward across North America, bison herds began to be hunted out in areas and were pushed to near extinction by the late 1890s (Dary, 1974; Geist, 1996; Sample, 1987). The development of the railroad and federal policies such as the 1862 Homestead Act sped the westward movement of settlers and the result was a loss of the buffalo (Licht, 1997). By 1840, most bison east of the Mississippi River were gone, and by 1880 most bison in the southern plains and east of the Missouri were also eliminated. 'The Great Slaughter' of bison occurred between 1870 and 1890. The US Army encouraged buffalo hide hunters and the railroad to increase the harvest of the buffalo which resulted in The Great Slaughter (Geist, 1996; Sample, 1987).

The chronological order of the decline of bison on the Great Plains was as follows (Danz, 1997; Dary, 1974; McHugh,1972; Rorabacher, 1970):

- 1848 – American Fur Company shipped 110,000 bison robes and 25,000 tongues to Europe
- 1860 – railroads were built separating the herds into the southern and northern herds; animals were killed to feed railway crews and army posts; Native people began to attack the trains or hunters due to the concern over the killings
- 1870s – new tanning process was developed; hunting bison for hides became very profitable
- 1868 to 1881- thirty one million bison were killed

- 1871 – trading robes and tongues became a major industry for some tribes; estimated two million bison were killed, and wiping out the Southern Plains herd
- 1872 to 1874 – average of 5,000 bison were killed each day
- 1883- by the middle of the year nearly all the bison were gone and only 40,000 hides were documented to have been sent East

Estimates are based on information from records of fur trading companies that recorded the number of hides shipped. These records show an average of 8,000 bison per day being killed for 20 years beginning in 1872. There was an estimate of only 1100 to 1300 bison left after the killing was stopped by government intervention from the US and Canada (Danz, 1997; Dary, 1974; McHugh,1972; Rorabacher, 1970).

During these years, the fate of the bison, in many ways, paralleled the fate of Native Americans as the Native Americans were defeated more so by the loss of their "commissary" than by the US Army (Rorabacher, 1970; Geist, p. 84, 1996). US Army General Phillip Sheridan described how killing the Indian's commissary to subdue them sealed the fate of both the bison and the Native people who relied on them.

General Philip Sheridan stated:

> (Buffalo hunters) have done more in the last two years, and will do more in the next year, more to settle the vexed Indian question than the entire regular army has done in the last thirty years. They are destroying the Indians' commissary; and it is a well known fact than an army losing its base of supplies is placed at a great disadvantage. Send them powder and lead if you will; but for the sake of lasting peace, let them kill, skin and sell until the buffaloes are exterminated… (cited in Danz, 1997, p. 112).

While millions of bison were decimated in the 1870's and 1880's, many Native people of the Great Plains were relocated to small isolated reservations. Similarly, the few remaining bison were placed on small islands of zoos, national parks and reserves (Mails, 1995; Danz, 1997). During the population low point in the late 1880s, only about 1300 bison remained in North America. This proved a serious genetic bottleneck that made it difficult to avoid inbreeding. Shaw (1993) estimates that there were only 74 to79 animals that provided the genetic foundation for all future tribal, federal and private herds in North America.

The Ghost Dance movement of the 1890s was based on the return of the bison to the Native people. Many tribes practiced it in hopes that the bison would return so that they would again have their spiritual icon, their provider. However the Ghost Dance eventually ended tragically at Wounded Knee in 1890 (Geist, 1996). Several decades had passed, but as McHugh (1972) notes, bison were still fresh in many Native people's minds, as reflected below, in the words of the Oglala Lakota, Crazy Horse (cited in Geist, 1996 p.136):

> My friend,
> They will return again.
> All over the Earth,
> They are returning again
> Ancient songs of the Earth,
> They are returning again.

Bison Re-Introduction

The population dynamics of exotic ungulates introduced to islands (Scheffer, 1951; Klein, 1968; Grenfell et al., 1992) and continents (Choquenot, 1991, 1998; Hone, 1994) show large population fluctuation. Sinclair (1977) and Mduma et al. (1999) found

that well established indigenous ungulates show less fluctuation in population. In comparing exotic and indigenous species, Sinclair (1977) reported that the variability in populations was less for indigenous than exotic when the same species were contrasted.

In 2000, Larter et al. studied the population dynamics of reintroduced wood bison in northern Canada. The population increased from 18 in 1963 to a peak of 2400 in 1989. The recolonization occurred through local increases followed by pulses of dispersal and range expansion. The results suggested that increase in range was due to competition for food among the herd. As a conservation strategy, they recommended the reintroduction of animals into several independent sites within their historic range.

Introduction of new species can change cultures and lifestyles. The introduction of horses by Spaniards into the southwest in the mid-1600s drastically changed the lives of Native people of North America, particularly those that relied heavily upon the bison. A shift to a more nomadic way of life was adapted by many tribes due to better transportation and easier hunting which led to less dependence on farming because the horse provided larger mobility. The enterprise of the horse allowed for many tribes to follow the large buffalo herds for most of the year (McHugh, 1972).

Accounts of bison being returned to their former range may have begun shortly after the turn of the century (McHugh 1972). Samuel Walking Coyote and his wife Sabine from the Pend d' Oreille tribe rounded up and maintained a small bison herd in Montana in 1878. Fredrick Dupuis, a French-Canadian, and his Minniconjou Lakota wife, "Good Elk Woman", and one of their children rounded-up bison calves sometime between 1880 and 1884 on the plains of South Dakota. Offspring from both of these

captured animal sites became the catalyst for future herds that eventually became part of the herds for the National Parks (Zontek 1995: Danz 1997).

William T. Hornday (1890), a naturalist and conservationist in the early 1900s, realized that if something wasn't done, bison would become extinct. In his book, *The Extermination of the Bison*, Hornday prompted the federal government to establish bison reserves and also organized the American Bison Society (ABS) in 1905 (Rorabacher, 1970; Danz, 1997).

By the 1930s, the American Bison Society had fulfilled their objective of saving the bison from extinction. They had also prompted the United States government to establish the National Bison Range in Montana. The National Bison Range is one of the oldest wildlife refuges in the nation. The original herd of bison was released on the refuge in 1909. This herd was purchased with private money raised by the ABS (Wildlife Conservation Society, 2007).

Hornday's 1889 survey counted 1,091 bison, Ernest Thompson Seton's survey counted only 800 in 1895 and 670 in 1927. In 1933, the American Bison Society conducted a survey with an estimation of over 20,000 animals (Haines,1970; Dary, 1974; Danz, 1997).

In the 1930s, several tribes were given the opportunity to reintroduce bison. Two of these tribes were the Oglala Lakota and the Crow. Records by the Bronx Zoo and the American Bison Society indicate that following construction of bison fence by the Civilian Conservation Core, the Pine Ridge Reservation, home to the Oglala band of Lakota, received bison from the zoo (Oglala Sioux Parks and Recreation Authority

Annual Report, 1997). In 1949, the tribal council of the Oglala Lakota sold the reintroduced bison herd, but reestablished the herd in the same area in 1972 (Callenbach, 1996).

During the late 20th century, several organizations arose to assist the private sector of bison producers. One of those was the National Bison Association (NBA) that formed in 1995, which was a merger between the American Buffalo Association and the National Buffalo Association. The NBA focuses on "…promoting bison and bison products; to seek regulations on disease and movements of bison and bison products and the promotion of bison." Other regional and state organizations have formed such as the Dakota Buffalo Association and the Great Plains Bison Association (National Bison Association, 2008).

The American Bison Society (ABS) became the Wildlife Conservation Society (WCS) and in 2005 celebrated their 100 year anniversary. Their mission continues to be the ecological restoration of bison with the many complex and modern challenges that bison now face. In October 2006, WCS organized a multi-stakeholder endeavor to focus on issues and concerns related to the ecological restoration of bison. This brought together leading institutions working on bison restoration. It included representatives from such institutes as the National Park Service, major universities, The Nature Conservancy, World Wildlife Fund, state agencies, tribal representatives and bison ranchers, to name a few. The mission was to develop a working paper that would address key elements in bison ecological restoration and the challenges that lie ahead as this North American icon returned to its former home. The working paper that was developed

begins to address the current issues related to bison management and restoration. It also gives a multiple perspectives of what the future restoration issues are as cited by scientists, private land owners, ranchers, Native Americans, federal, state and provincial agencies and non-profit conservation groups. Among the issues addressed included preservation of a "pure" species of buffalo, ecological significance, and recovery potential of bison across North America. (Wildlife Conservation Society, 2007).

The Inter-Tribal Bison Cooperative was founded in 1992 to assist Tribal bison projects. ITBC's mission is to "restore bison to Indian Nations in a manner that is compatible with their spiritual and cultural beliefs and practices and to reestablish healthy buffalo populations on tribal lands". With the formation of the ITBC, many tribes established bison herds. With funding designated by Congress, 57 tribes either have bison or are in the process of acquiring bison. Collectively, tribes across the United States have approximately 15,000 bison. There is an on-going effort by tribes to restore bison to tribal lands and to assist tribes in having successful and self-sufficient bison operations (InterTribal Bison Cooperative, 2007).

Ecological Assessments and Impacts

Much of the North American prairie developed under the influence of large grazing herbivores and sweeping prairie fires. There was a climate, plant, fire and bison interaction that influenced prairie evolution, particularly in the Great Plains region (Vinton et al., 1993). This in turn, shaped the structure of the plant community (Axelrod 1985; Dyksterhuis 1958; Weaver 1968; Risser et al. 1981). Many early herbivores were browsers and may have contributed to the development of the grassland biomes that supported bison population growth (Hartnett et al., 1997). Most of the primary region that once contained millions of bison now has either been turned into farmland or is grazed by cattle (Danz, 1997).

The grasslands of the Great Plains region are divided into three grassland formations that include the tallgrass, mixed-grass and short grass prairie. The Great Plains region is the primary area of North America that was habitat for bison. The Great Plains area is known for severe weather, unpredictable moisture and wind (Borchert, 1950; Sims and Risser, 2000).

In the northern Great Plains, mixed-grass prairie lies in western North and South Dakota. The extreme climate fluctuations make it a dynamic ecosystem. The mixed-grass prairie is a blend of tall grass and shortgrass prairie vegetation. The mixed-grass prairie, that was the primary focus area for this study, constitutes some of the most diverse grasslands of the world. It has the richest floristic complexity of all the grasslands (Barbour et al. 1987). Mixed grass prairie can be divided into three communities

correspond to soil type, topography, and position along a moisture gradient. (Redmann, 1975).

As bison are being reestablished on the plains, research has begun to investigate the effects of grazing on the ecosystem. Bison are graminoid feeders and often consume more of the dominant grasses than would be predicted by availability (Steuter et al., 1995). This preference may result in an increase in forb density, a key component for maintaining a high level of biotic diversity in tall-grass prairie (Turner et al., 1995). Consumption of browse or woody vegetation may have played a key role in the rise of the grasslands following the Pleistocene age and therefore increased the population of bison (Axelrod, 1985; Hartnett et al., 1997). Turner et al. (1995) view species richness as critical for a high level of biotic diversity. The higher the number of plant species, the greater potential for increased annual diversity. Bison can therefore be a critical factor by allowing forb species to flourish and providing habitat for species that rely upon forbs. Coppedge et al. (1998), examining bison diets through fecal analysis, reported bison preference for grass and sedges. This supports conclusions of Fahnestock and Knapp (1994) that bison grazing (in patches compared to ungrazed patches) enhanced water availability and productivity of forbs. Bison may also play an intricate role in altering competition between C_3 forbs and C_4 grasses. The shifts can be important for the structure of the plant community with grazing, or lack of grazing, and fire playing roles in the dynamics of certain grass species (Knapp, 1985; Briggs and Knapp, 1995).

Damhoureyeh and Hartnett (1997) studied the effects of bison and cattle grazing on plant growth, reproduction and species abundances. They concluded that effects on

forb growth and reproduction were significantly different due to ungulate species. Plant growth response also varied by plant species with some species increasing growth after grazing and other species showing growth decline. However, in a study by Stohlgren et al. (1999), results indicated little difference in native vegetative species richness due to grazing (compared to exclosures). Stohlgren et al. (1999) found that environmental factors such as soil characteristics and weather had a greater effect on species diversity than levels of grazing. Hartnett et al. (1996) indicated that the effect of bison grazing on species diversity was greater with increasing sample area.

Bison do not graze indiscriminately across the prairie (Wallace et al., 1995). In tallgrass prairie, Catchpole (1996) found that bison graze in distinct patches of 20-50 m^2 and McNaughton (1984) reported larger grazing lawns of more than 400 m^2. Grazing has been found to influence re-growth of some grass species so that initial responses to grazing may be different than long-term effects. Vinton and Harnett (1992) found that in the first year of grazing, *Andropogon gerardii* (big bluestem) was able to completely compensate in growth and biomass by season's end. Turner et al. (1993) reported regrowth was able to compensate in newly grazed sites, but not in sites that had been heavily grazed in previous years.

Peden et al. (1974), found differences in consumption of dietary crude protein between grazing bison and cattle. They found herbivore selection between C_3 (cool-season) and C_4 (warm-season) plants differed. According to Plumb and Dodd (1993), bison selected vegetation to take advantage of changes in forage quality and quantity.

Also, bison consumed most of the plant parts and rarely discriminated against one part of the plant or another.

Day and Delting (1990) showed that grasses growing on urine patches in mixed grass prairie have higher leaf nitrogen content than those without urine. Steinhauer (1994) found that plant quality may impact patch selection by bison. In experiments comparing grazed and ungrazed areas which had been randomly treated with bison urine, bison preferentially grazed areas treated with bison urine. Soil type may impact the percentage of crude protein and fiber as well as the ratio of cool or warm season grasses. Heitschmidt et al. (1995) classified ecological conditions by soil type. Soil organic matter (SOM) levels can vary by soil type, plant community and climate, according to Reeder et al. (1998). This also affects the C_3 and C_4 plant dynamics. The shift from a C_3 dominant plant community to a C_4 dominant plant community is usually reflected by an increase of carbon within the soil (Coupland & Van Dyne, 1979, Frank et al. 1995). Soil organic matter and carbon and nitrogen (C:N) ratio are also affected by management inputs and grazing intensity. Increases in soil organic carbon can assist in binding soil particles; increase soil fertility and therefore plant productivity; and reduce soil crust formation. Light to moderate grazing can increase SOM and therefore increase the overall productivity of the forage (Karl et al., 2006)

The quality of rangeland soils presents both “challenges and opportunities” (Herrick and Whitford, 1995) for assessment. Range soils, when compared to cropped soils, tend to vary more spatially and temporally and have more diverse land use. Climate and topographic variation have a large effect on soil formation and nutrient cycling

within a grassland ecosystem. In turn, soil type has been shown to influence plant species composition and to have an affect on size and density of plants as well (Heitschmidt and

Stuth, 1991). Herbivores also are very important in soil nitrogen cycling and compound the effects of climate and topography on soil nutrients (Frank and Groffman, 1998).

Grazing can lower the organic carbon, nitrogen and phosphorus in the soil compared to ungrazed soils, however this can depend on the intensity of grazing and the type of soil. Soil features, such as bulk density, and topsoil organic matter and nutrient contents are affected by livestock grazing. Hiernaux et al. (1999) reported that grazing resulted in reduction and fragmentation of crusted soils. As a result the infiltration index for soil increased slightly with moderate grazing, but decreased with higher stocking rates. Soil bulk density was shown not to be affected by grazing except at lower depths (>10 cm). When comparing ungrazed to grazed, pH, organic carbon and nitrogen concentrations and to a smaller extent phosphorus concentration decreased after four years of grazing. Soil phosphorus and pH continued to decrease over a longer time period and with higher grazing pressure (Hiernaux et al., 1999). Grazing and intensity of grazing alters the nitrogen cycling in soils. Bison grazing reduced combustion losses of nitrogen during fires (Hobbs and Mooney, 1991) and reduced the C:N ratio of the roots, thus reducing microbial immobilization in the soil (Milchunas and Lauenroth, 1993). These changes in nitrogen cycling concur with the results of Steinhauer and Collins (1995) who concluded that the net effect of bison grazing was an increased rate in nitrogen cycling and a significant increase in spatial heterogeneity. Grazing also has an

impact on soil organic matter due to reduced litter accumulation and in turn a reduction in the soil carbon and nitrogen contents (Schuman et al. 1999).

Climate and topography have a large effect on the grassland ecosystem, however the impact that large herbivores have on the nitrogen dynamics within the soil is less understood. Frank and Groffman (1998) found that the variation in net nitrogen (N) mineralization among sites that were diverse was a factor of immobilization rates and that grazers affected the gross mineralization rates. It was found that the grazer increased the average net N mineralization and total mineralization rate, and greatly increased between-site variation of that rate (Frank and Groffman, 1998).

The structure of the soil is determined by the strength, size, shape and arrangement of the peds or the pedality of the soil (Brewer, 1964). With grazing, prairie soils may lose their granular structure and develop blocky and platy structures (Wiermann et al., 1999). Peds were found to be finer (size) and stronger (grade) under grass than in cultivated areas in South Dakota (Eynard et al., 2004). Aggregate stability is an indicator of levels of organic matter, biological activity and nutrient cycling in the soil (USDA, 2001a) and is often included in measures of soil quality.

Soil moisture is a limiting factor in most rangeland systems due to low and extremely variable annual precipitation and high summer evaporation. This in turn affects the soil properties, species composition and population structure. These patterns of precipitation affect soil nutrient immobilization and mineralization, aggregate formation and stabilization. Soil moisture varies among seasons, plant communities and years (Herrick and Whitford, 1995).

In summary, the bison and the land they inhabit interact with each other. Soil and forage are directly impacted by the effects of bison grazing in terms of nutrient cycling, plant diversity, and other soil properties. As bison continue to increase on the landscape, their presence will shape the environment.

Bison Management

As the commercial value of bison plummeted in 2000, there was an even greater need by Tribal bison managers for information on how to raise bison in an ecological, cultural and economical way that would not compromise the spiritual connection that bison historically played and continues to play today (USDA, CSREES and Tribal Colleges Research Grants Program, 2003). Spiritual values and their relationship to natural resource management are rarely discussed among mainstream cultures, however it is important to the connection between Native Americans and bison management (Bengston 2004). Several of the tribal colleges that were part of Northern Plains Bison Network (NPBEN), and South Dakota State University (SDSU), piloted a project that dealt with the unique issues of tribal bison management. Through this effort the *Homeland Indigenous Philosophy* was defined. This philosophy embraces Native American perspectives that the bison are sacred to the indigenous Tribes of the Northern Plains; that bison are to be respected as relatives of life systems; that bison have a major role in establishing balance in ecosystems; and that there should be a "care-taking versus management approach to bison" (USDA CSREES, and Tribal Colleges Research Grants Program, 2003).

The recovery of bison populations throughout North America represents a success story in conservation and restoration biology. The highly publicized near extermination of bison in the late nineteenth century is well documented and nearly led to the extinction of the last remaining North American members of the genus *Bison bison*. The population crash of bison, which occurred between 1860 and 1905, reduced population numbers from at least 30 million to only a few hundred individuals (Berger & Cunningham, 1994). A few of the last bison were kept in Yellowstone National Park. The American Bison Society was not only responsible for taking a few remnant bison to the Bronx Zoo, but was also instrumental in lobbying Congress to set up refuges for the bison. There are now four national wildlife refuges that have bison herds: Wichita Mountains, OK; the National Bison Range, MT; Fort Niobrara, NE; and Sully's Hills, ND (Danz, 1997). Most of the refuges sell excess bison through a public auction each year. They are also supported by donations and tax-supported organizations.

Many of the few remaining bison that were left after the 1880s were sent to national preserves. Some of those bison later became starter herds for the National Park Service. Today the National Park Service is a large contributor to the success of the public herds. The National Park Service maintains bison herds of 5000 to 7000 animals within five parks that include the Badlands in South Dakota, Grand Tetons in Wyoming, Theodore Roosevelt in North Dakota, Wind Cave in South Dakota, Yellowstone National Park in Wyoming and Montana and Chickasaw National Recreation Area in Oklahoma. Most national parks and refuges have the bison in fenced areas, except for Yellowstone National Park. This has caused problems due to bison coming out of the park during

certain times of the year. The Yellowstone herd and Grand Teton bison herds have brucellosis, which is a cattle disease carried by a bacteria that causes the cow to abort the calf (Danz, 1997). A harsh winter in 1996-97 caused hundreds of bison in Yellowstone to come out of the park looking for forage. Many of those animals were destroyed due to the possibility of the bison transmitting brucellosis outside of the park to other animals such as cattle (Cheville, et al. 1998).

There are also numerous state herds such as the Henry Mountains in Utah which are actually held by the Bureau of Land Management (BLM). New Mexico maintains a herd on BLM land. Kentucky and Kansas also maintain bison herds on federal lands. Custer State Park in South Dakota and Antelope Island State Park in Utah maintain herds of bison. There are numerous smaller bison herds that are held in states such as Alaska, Nebraska, Missouri, Minnesota, Wyoming, Colorado and Arizona. Many have live bison sales that are held each year. There is also an array of sealed bid sales and video auctions that are part of many of the state parks management efforts.

The management of bison within the national park system varies; the Yellowstone herd by far being the most wild and kept in the more natural way with little interference or management. Due to the brucellosis issue within Yellowstone National Park (YNP), there are concerns related to the surplus bison that run within the 2.2 million acres of the park. The InterTribal Bison Cooperative has offered to take bison after a quarantine period and disease testing protocol from YNP, this is currently being discussed according to Mike Fox, former interim director of ITBC (personal communication, July, 2007).

Other than YNP, many of the parks do have a fall roundup; vaccination takes place, and weighing and identification of animals is done at that time. The national parks and refuges that have bison see them as a key element in maintaining the health of the grasslands within the parks. Most of the parks and refuges are devoid of one important element to maintain overall ecological diversity, large predators. Only Yellowstone has predators such as wolves and grizzly bears that may make an impact on overall herd health on a natural culling basis. The parks and refuges on a whole also have a no-feeding or supplement policy, except maybe a salt and mineral block (Callenbach, 1996). The herds are maintained under a strict genetic conservation plan that includes testing for bovine genes within the herds. This is an intense plan to maintain a healthy genetic structure among of the five national park bison herds. The goal is to maintain as pure a bison genetic code as possible for the long term viability of a genetically pure bison. The National Park Service is also discussing disease control and eradication of brucellosis by identifying genes that may control brucellosis and other diseases (Wildlife Conservation Society, 2007).

After the National Park Service herds are rounded up, many excess animals are given to tribal bison programs through the InterTribal Bison Cooperative. Some of the tribes have individual agreements with the National Park Service (Hill, 2007 personal communications).

The Nature Conservancy is also an active participant in bison management and is particularly interested in ecological diversity. The Nature Conservancy is a large nonprofit, international organization that manages large tracts of land throughout North

America and around the world. The Nature Conservancy has approximately 3,800 bison that are on nine preserves totaling 53,000 acres (Wildlife Conservation Society, 2007). Five of those preserves are: Samuel H. Ordway Memorial Prairie Preserve in South Dakota; Niobrara Valley Preserve in Nebraska; Cross Ranch Preserve in North Dakota; Konza Prairie Research Natural Area and the Tallgrass Prairie Preserve in Oklahoma. The Nature Conservancy management philosophy strives "to maintain areas of high ecological diversity by using those animals that historically and originally maintained that diversity" (Wildlife Conservation Society, 2007). The mission is to preserve plants, animals and communities within the conservation strategies outlined for the ecoregion. Therefore, the preserves that maintain bison are largely within the Great Plains ecosystem, and they use bison as a natural large ungulate grazer. However, some of these same preserves also maintain cattle herds. The strategy is to mimic the natural process that shaped the grasslands of North America with the use of fire, bison grazing and climate. The Nature Conservancy also uses a science based approach to all management decisions based on ecological research. Like the National Parks Service, they want to maintain a genetically viable species (Wildlife Conservation Society, 2007).

The Nature Conservancy Preserves usually have a round-up each fall and weigh and ear-tag all calves. All surplus bison are sold by sealed bid. There is no public hunting. All calves are kept the first year, but older animals are culled during that time. Animals with poor vigor are removed as well as the excess males. Animals are also tested for any diseases such as brucellosis and tuberculosis and culled if there are any positive animals. The typical fence for the Nature Conservancy is usually between 5-6 ft tall

barbed wire. Bison numbers vary according to forage availability and assessment (Hamilton, 1993).

Ted Turner's land holdings are approximately 2 million acres, comprised of 15 ranches in seven different states (Colorado, Kansas, Montana, Nebraska, New Mexico, South Dakota and Oklahoma). Turner's herd is the world's single largest, numbering approximately 45,000 head. His philosophy is to allow natural processes to occur, however he realizes that man plays a heavy hand in these processes. He also manages his lands "in an economically sustainable and ecologically sensitive manner while promoting the conservation of native species." The bison on Turner's ranch are handled as little as possible. He primarily butchers three and four year old bulls that are used in his restaurants (Turner, 2007).

Turner also promotes other uses of his bison ranches which include commercial fishing and hunting and some timber harvesting. Therefore, he has supported re-introduction of critical species to the land such as swift fox (*Vulpes velox*) and allowed other keystone species such as the Black-tailed prairie dog (*Cynomys ludovicianus*) to remain on his holdings (Turner, 2007).

Jack Norland (2001), researcher in the Department of Animal Sciences for North Dakota State University provided recommended practices for bison herd management. He recommends that the stocking rate for pasture and range be comparable to domestic cattle, so a 1000 lb cow with calf at side was equal to one Animal Unit Month (AUM). Generally, Norland recommends a herd manager should maintain a stocking rate that utilizes 50% of the forage and leaves the other 50% for plant vigor and wildlife. He also

recommends leaving up to 80% if the bison were to remain on the pasture or range year round. This would allow for adequate winter forage when the plants are not actively growing. Norland suggests that bison managers could increase the number of bison if the pasture is large. Bison, Norland argues, can utilize a larger pasture more efficiently than cattle due to the bison's ability to move around and distribute themselves more efficiently in larger areas. Norland also suggests that pregnant female bison can meet their nutritional needs through 2/3 of the gestation, but recommends supplementation of protein in the last part of pregnancy (Norland, 2001).

The gathering of 19 Indian Nations took place in the sacred Black Hills of South Dakota in 1991 to unite for one common mission: "to restore bison back to their former lands". With this meeting began the formalization of the InterTribal Bison Cooperative (ITBC). Today the membership is 57 tribes who collectively support 15,000 bison. The role of ITBC is to "establish membership; act as a facilitator in coordinating education and training programs; develop marketing strategies; coordinate the transfer of surplus buffalo from National parks to tribal lands; and provide technical assistance to its membership in developing sound management plans that will help each tribal herd become a successful and self-sufficient operation" (InterTribal Bison Cooperative, 2007) ITBC does not dictate to tribes how to manage their bison herds, but rather, provides information to assist tribes with their particular areas and herds. They give no guidelines on stocking rate, vaccinations or any management practices. ITBC through a granting process helps to provide money to increase and sustain bison herds for member tribes (Hill, 2007 personal communications).

It has now been estimated by the Wildlife Conservation Society (WCS) that there are approximately 450,000 bison within North America. The WCS believes that the bison restoration effort has been a conservation success story. However, 95% of these animals are raised under confinement and in various management settings. Few bison are actually managed for ecological gain "to create habitat or provide food for other native species" (Wildlife Conservation Society, 2007). The future of bison rests in many different hands with Native Tribes being only a fraction of the equation. However, with multi-staked efforts, the future of the bison may continue to improve. Native people have and will continue to play a role in the evolving history of bison management. An improved understanding of the range of the factors impacting contemporary approaches, practices and outcomes of tribal bison reintroduction is needed.

Chapter 3. Methodology

Introduction

A descriptive case study (Berg, 2003; Yin, 2003) approach was utilized to develop a deeper understanding of issues associated with the research goals and objectives. This descriptive method is a 'patchwork case study' of multiple research sites which together provide a comparative understanding of different approaches to tribal bison reintroduction. The case study method is appropriate for these objectives because it provides an in-depth understanding concerning questions of 'how and why' and because of the exploratory, cross cultural nature of the research (Berg, 2003; Yin, 2003). Further, the case study approach fits the project objectives well because it sets the stage for larger research projects, provides a deeper level of analysis, and deeper explanations and insights toward a better understanding of issues associated with tribal bison reintroduction (Burns, 1990).

The case study method provides a descriptive, holistic snapshot in time of four different approaches to re-introducing bison to tribal lands. Methodological triangulation was employed to enhance understanding of the projects' recent history, current reality, and insights for the future. The information gathered weaved together a complex array of data and perspectives on tribal bison reintroduction. Qualitative and quantitative data collection was multidisciplinary in nature, including information and insights on issues relating to ecology, range, management, economics and culture.

A case study should include a conceptual framework, a research a plan, data collection, and analysis (Cepeda and Martin, 2003). The focus of this study was the interaction among management, ecology and culture for re-introduction of bison to tribal lands. The case study included four unique sites that are separate research years that use the same methods to describe them. Results were integrated across the sites to determine a more complete understanding of Native American bison reintroduction. The final part of the case study was a critical analysis which involved a synthesis of both qualitative and quantitative results leading to a deeper, more integrated understanding of bison reintroduction among Native Americans.

Research Objectives:

The overall goal of this study was to explore and document issues of sustainability associated with the reintroduction of bison by American Indians. This goal was further explored through the following research objectives:

1. To identify management practices associated with the sustainability of bison introduction by American Indians;

2. To explore the role of American Indian culture in the management of bison for sustainability;

3. To investigate rangeland criteria that could be used to measure sustainability of bison reintroduction by American Indians.

This study was conducted using research triangulation including qualitative materials and rangeland biological data with multiple sources of evidence. Triangulation methodology enhances the validity and reliability of results and allows multiple methods to come to a more precise conclusion about the re-introduction of bison to the Reservations in South Dakota.

Qualitative Data Collection

To explore research objectives one and two, a series of in-depth, qualitative interviews were conducted with the bison herd managers associated with each of four research sites. After review of the literature and preliminary discussions with industry, academic and tribal personnel, a 41-question interview guide was developed. The major sections of the interview guide were 1) general background on bison management practices; 2) land and ecological issues associated with the enterprise; 3) economic issues; and 4) cultural considerations. Sample questions from each section are listed below:

Section 1: General background on bison management

Sample questions:

- How would you describe your overall management approach to your herd?

- Could you please walk me through a typical year of herd management?

  Probe questions –

  a. What is your approach to feeding? (grass, supplement, feedlot, etc.)

b. What is your approach to animal health? (vaccinations, veterinary care, etc.)

c. What is your management during breeding season, calving season, etc.?

d. Do you round-up? Wean calves? Vaccinate? etc.?

e. Do you identify your animals? By Tag? Chip? Other methods?

- When making decisions about management, what are the top priorities?

Section 2: Land and ecological issues associated with tribal bison reintroduction

Sample questions:

- In your opinion, what is the overall condition of your pasture?

- How do you make decisions on stocking rates?

- Describe your grazing system.

Section 3: Economic issues associated with tribal bison reintroduction

Sample questions:

- What are the economic goals of your bison project?

- How do you market your animals?

- How would you describe the financial health of your operation?

Section 4: Cultural considerations in tribal bison introduction

Sample questions:

- Do you have cultural goals associated with your bison project?
- Do cultural considerations impact your approach to bison management?
- Do you use ceremony as part of your bison management?

Questions were open-ended in nature and designed to elicit a 'thick description' from the unique perspectives of each of the respondents. The purpose of the interviews was to provide a deeper understanding of different approaches to tribal bison management being implemented across the state on four different bison operations on three different Reservations in South Dakota. This interview guide was reviewed and a consent form was approved by the Human Subjects Committee of the Institutional Review Board at South Dakota State University.

Each interview was conducted face-to-face, onsite near the bison project under examination. At times, probe and follow up questions were asked to elicit more detailed responses. Subjects were also invited to add additional comments at the conclusion of the formal interview. Hand-written field notes were taken during the interview and the full notes were transcribed. These transcribed notes were transcripts of what was said by each of the four persons interviewed. The name of the bison manager and specific identifying details of each operation were kept confidential. Psuedonyms are used for the presentation and discussion of results that follows.

Qualitative Data Analysis

Qualitative interview data was analyzed through "pattern-matching" and coding (Yin, 2003). Coding involved reading the transcripts and putting each question from each site in a table so that themes could be identified and then coded according to overall management, ecological factors, land issues, economics and cultural/spiritual considerations. The complete interview transcripts were also analyzed for sub-themes and or new themes that might emerge from the data. Each theme or pattern was given a separate color code. Based on this analysis, a descriptive case study was produced for each site. No direct comparisons were done on data collected, but patterns that emerged as results were analyzed, following Yin's (2003) approach for cross-case synthesis. As such, each case was treated individually, but as part of the same larger study. Overall patterns emerged that more clearly defined the sustainability process of each site as it related to management and cultural issues that may be unique to tribal bison reintroduction. Common themes identified in interviews across all cases were integrated with biological data and are discussed in the concluding chapter.

Research Site Description

Four ranges, one from each of the Case Studies which had recently re-introduced bison, were selected for investigation. Each range had previously been part of a cattle operation. Management was unique for each range, and included management by a tribe as described below. All ranges were located on tribal lands within the state of South Dakota.

Four research sites were selected (one within each Case Study range) for baseline data collection in 2003 and 2004. At each site 30 X 30m plots in shoulder-, toe-, and mid-slope positions were established with three replications. At the mid-slope position, an exclosure was built in order to compare grazed and non-grazed range. Replications, as much as possible, were selected for similarity in soil type, slope, and aspect.

Case Study I, Tribal Community Bison, was managed through a family cooperative and was located within a 700 ha range unit that had been stocked with approximately 50 bison since April of 2002. The research plots were on an Oglala-Canyon soil association on 18-40%, east-facing slopes. The predominant Canyon soil series is shallow, steep, friable, light-colored, medium textured and calcareous.

The plant species were a mixed grass community dominated by *Agropyron smithii (*western wheatgrass*)*, *Stipa commata* (needle and thread grass), *Bouteloua gracilis* (blue grama)*, Schizachyrium scoparium* (little bluestem) combination with intermittent areas of forbs surrounded by savanna type landscape of *Pinus ponderosa* (ponderosa pine) (Johnson and Larson, 1999).

Case Study II, Tiospaye Bison, was individually managed and was located within a 1000 ha range unit that had been lightly stocked since December of 2000. The plots were on an Oglala-Canyon soil association on 18-40%, north-east facing slopes. The predominant Canyon soil series is shallow, steep, friable, light-colored, medium textured and calcareous.

The plant species were a mixed grass community dominated by *Agropyron smithii (*western wheatgrass*)*, *Stipa commata (*needle and thread grass*), Bouteloua gracilis (*blue grama*),* and *Schizachyrium scoparium (*little bluestem*)* combination with intermittent areas of forbs surrounded by a savanna type landscape of *Pinus ponderosa* (ponderosa pine) (Johnson and Larson, 1999).

Case Study III, Tribal University Bison, was managed by a Tribal University and was located within one of the range units rotated with approximately 300 bison. The plots were on an Anselmo-Tassel-Dunday soil association on 5-9%, east-facing slopes. The predominant Anselmo soil series is deep and well drained. The soils are formed in wind-deposited sandy material that is friable when moist.

The plant species were a mixed grass community dominated by *Agropyron smithii (*western wheatgrass), *Stipa comata* (needle and thread grass). *Bouteloua gracilis (*blue grama)*, Schizachyrium scoparium* (little bluestem).

Case study IV, Tribal Bison, was managed by the Tribal Fish and Wildlife Agency and was located within a 530 ha range unit that had been stocked with approximately 80 bison since 1995. The plots were on a Sansarc-Opal soil association on 6-15%, east-facing slopes. This soil association is formed in clayey shale residuum. The predominant series are moderately deep, well drained and steep. These clay soils have gray shale within one meter of the surface.

The plant species were a mixed grass community dominated by *Agropyron smithii* (western wheatgrass), *Stipa comata* (needle and thread grass), *Bouteloua gracilis* (blue grama), and *Schizachyrium scoparium* (little bluestem).

Quantitative Data Collection

Experts from the Society of Range Management and National Research Council (Pyke et al. 2002) published three categories for defining and measuring rangeland "health". The three criteria were: degree of soil and site stability; hydrologic function; and biotic integrity. This framework has been used to refine criteria and apply them to rangelands.

The Sustainable Rangelands Roundtable (SSR) (Karl et al., 2006) included maintenance of soil and water resources as criteria to determine if current rangeland management promoted sustainability. They recognized the need for a set of indicators that could be monitored over time to assess change resulting from management practices. The list of soil based indicators included soil organic matter and aggregate stability as descriptors of nutrient and water availability and erosion resistance, all of which subsequently impact plant composition and productivity. In their assessment they concluded that the methods for measurement of soil organic matter are available and adaptable to both the regional and national level. They cautioned that although methods of measurement for aggregate stability were available, data interpretation should be limited to the site scale and not extrapolated to a regional scale. They also emphasized that although aggregate stability is sensitive to management practices, and therefore a good indicator, it is not well understood by stakeholders. Thus the role of aggregate

stability as an indicator of erosion potential needs to be emphasized. In our study, we measured a combination of soil indicators as well as plant productivity and diversity. We combined these analytical measures with qualitative data describing management practices and philosophies to provide a baseline against which sustainability could be determined in the future.

Both soil and plant criteria were used to determine sustainability. Soil samples were collected in May of 2003 and 2004. In each plot, four sub-samples were collected at 0-20 cm depths and pooled. The soil quality factors measured included soil chemistry, gravimetric soil water content, and air dried aggregate stability. Soil analyses for organic matter, pH, soluble salts, nitrate - N, Olsen P, and K were done by the SDSU Soil Test Laboratory (NCR Pub 221, 1998). Aggregate stability was determined using the methods of Kemper and Roseneau (1986).

Vegetative samples were collected in July at peak production. Three - 0.3 m square samples were randomly selected in each plot and top growth was removed at soil level. Samples were dried at 60 degree C and analyzed by SDSU Station Biochemistry for moisture, crude protein, acid detergent fiber and neutral detergent fiber (North Central Research Publication No. 221 revised, 1998).

A plant survey was completed and species were categorized as grass or grass-like, forb, or woody. Surveys (Hitchcock, 1971) were conducted in July, during peak standing crop, to ensure that both C_3 and C_4 plant species were adequately represented. Each plot was divided into1 m grids by visual estimates. A randomly selected 1 X 1 m subplot was searched; then doubled to a 2 X 2 m subplot and searched again; then doubled to a 4 X 4

m subplot and searched; then to a 16 X 16 m subplot and searched; and then finally to the 30 X 30 m plot and searched. Species were recorded at each sub plot and each time a new plant was located and identified to the species level it was added to the field list. If a plant was not readily identified by sight, it was collected, labeled, and taken back to the laboratory for identification (Stubbendieck and Schacht, 1997). Fewer than 5% of the species encountered could not be identified to species, due to phenological stage or missing plant parts. All plant species identified from the plots were combined and a list was prepared for each site.

Statistical analysis was completed using SAS (1985). The LSD at a probability of greater F level of 0.05% was used to compare differences between the treatment means. Rangeland quality data were integrated into each case study to provide a broader understanding of each operation.

Quantitative results are integrated with interview results in the discussion of overall project conclusions in the concluding chapter.

Chapter 4. Results and Discussion for Case Study I – Tribal Community Bison

Introduction

Case study I was managed through a family cooperative and was located within a 700 ha range unit that had been stocked with approximately 50 bison since April, 2002. The bison project was developed through a family/community project and the main goal was to bring the bison back to the area for the people and for the land. The original herd of bison was started from a local bison rancher under a contract agreement. The pasture was leased through the Bureau of Indian Affairs (BIA), but was originally one of the allotments for the family that was later traded for other lands closer to the main road. Stocking rate was set by BIA regulations for the area which is typically 40 acres per AUM. The entire pasture was fenced with six strand barb wire that was approximately 1.6 m high with most of the posts being railroad ties.

Management style was typically a hands-off approach with year long grazing and minimal supplemental feeding or handling. There was no vaccination program or disease testing. The herd manager believed in a stress free environment with the health of the animals and surrounding natural resources taken into consideration on all management decisions. The community was interested in ecotourism as part of the management to provide revenue and jobs. There was also an interest in the habitat, wildlife, and trees. Youth education and community involvement were part of the overall management approach and much of the original fence was done by community volunteers. The concerns of the project were the overall health of the herd and the environment; lack of another source of water in the pasture; genetics of the herd; and wild fires.

The herd was supported mostly by selling of hunts and outside donations. The case study manager was very interested in helping to get bison meat back into the diets of the Lakota people at a price they could afford. Nutrition of the people and nutrition for the animals were top priorities.

Background

A face-to-face, in-depth interview was conducted with 'Joe', the bison manager associated with Tribal Community Bison, an enrolled tribal member. Joe described his own introduction to bison management as largely circumstantial, sharing how his sister had started the project and then needed to move away, creating a need for a manager.

> I kind of had to step in…basically, I got in it by circumstances.

Joe's background, having grown up around cattle production, provided important experience. He discussed his own growing interest and sense of pride in working with buffalo.

> I got interested in it and the more I was around it the more I liked it and wanted to be around them (the bison).

> Just getting the animals here and still having them here…(is an accomplishment).

Responses to interview questions for Tribal Community Bison are presented and discussed according to the research objectives described below.

Research Objective One

To identify management practices associated with sustainability of bison introduction by American Indians.

Management practices associated with sustainability were explored through a series of questions regarding overall management, land and ecological issues, and economic issues.

Overall herd management

Several themes emerged from the interviews that could be associated with overall herd management of Tribal Community Bison. First was an overriding concern for the well-being of the bison. In discussing the year's activities, Joe described his particular concern for the animals during the winter months.

> …I am just chasing them around (laughs)…that is what my winter chore is. I am concerned with what the animals are doing…I am really concerned with where they are. Watching the animals and taking care of them.

When asked about management priorities, his response was clear.

> The management…take(s) the animal into consideration first. Any time you want to do something, you need to take the animal into consideration first.

A second, related theme, was a non-intrusive, 'hands-off' approach to herd management. Joe said: "I really want them to do their own thing."

In relation to feeding, he commented: "I just let them go where they want and try to supplement them as little as possible."

While Tribal Community Bison did provide supplemental feed ('cake') during times of nutritional stress, the operation's approach to disease management was more absolute. In describing the approach to herd health with Tribal Community Bison, Joe responded plainly: "No testing. No vaccinations."

Joe went on to discuss a management approach that minimized stress on the animals and strived to keep bison family units together, even if this meant keeping older animals in the herd beyond their years of peak production. This impacted management in other ways.

> Hey, I don't want to run them like cattle. I don't want to inject them…I don't want to wean the calves. I want the mother and calf to stay together as long as possible.

In summary, he said: "We want to mess with them as little as possible…(and let them) do their job."

Joe also discussed 'outside the fence' factors impacting herd management.

> The human side of things…and you are dealing with other people and agencies. Tribal, cattle operators, and other people that are raising buffalo, so you are not just dealing with raising the animal but with other aspects.

While some of these interactions were 'complicated' and 'challenging', Joe expressed a positive attitude toward his work with other bison producers.

> I am amazed about the people that raise buffalo, they are more open minded… they talk.

Environmental sustainability

As was the case with his concern for the buffalo in his herd, Joe was interested in the well-being of the natural environment. This was a particular issue given drought conditions which were predominant in the region during the time of the research. Joe, who described the condition of his pasture as "pretty fair", but "excellent…given the drought we have had…" said, "I am really interested in the environment…and the drought has really had an effect on the grasses."

Joe was particularly interested in the web of relationships and interactions that he saw as critical to the health of the ecosystem on his pastures.

> …The trees and all the animals and how they interact and get an inspiration from the animals and figuring out what kind of relationship they have with others…The management is really interesting.

He continued:

> It seems to me that I have seen more…wildlife, more turkeys, more grouse, and more birds.

Joe attributed this change to the re-introduction of bison:

> I think because of the buffalo and the management we have kept enough grass and enough cover (for them). So the animals like that.

Comparing his pasture to nearby cattle ranches, Joe said:

> I look at other pastures with cattle and they are really beaten down bad…but us having the buffalo here…I believe has increased the overall health of the land.

While he discussed the possibility of expanding his herd, Joe understood this could only come with an expanded land base, which would be important for maintaining overall herd health. He expressed further concerns over the health of diseased pine trees, and the possibility of fire.

> That way, I would like to keep the numbers where there is enough grass to keep them comfortable…Increase the land base, there would be more comfort and less stress (among the bison).

Working with Tribal Community Bison allowed Joe to spend more time outdoors in the natural environment. He commented:

> The thing I like about raising buffalo is it has got me closer to the land.

Economic sustainability

Economic considerations were secondary from the management perspective of Tribal Community Bison, however, herd finances were important to the project's sustainability. Joe described the financial health of his herd as 'fair'. Economic challenges included paying land leases and costs such as fencing and providing water sources. However, as he explained, he and his community did not have to rely on the buffalo herd economically.

> …I really don't have to depend on the animals to have to become a commercial herd and depend on them to make it for us…sell all the animals to pay for stuff.

He did, however, articulate his desire to make the operation economically sound.

> I would like to be self-sustaining and make a living off it.

The discussion of herd economics quickly shifted to a broader definition of sustainability.

> I would like to take care of the land and make a living off it…(I would like to have the operation be)…self sustaining and so we can pay our bills and have the animals and be able to take care of them.

Currently, some animals from Tribal Community Bison are sold each year to help finance the herd. In addition, some meat is sold locally, and some hunts are sold. He described marketing as a challenge.

> Right now, it's kinda tough because the market isn't always there.

"We give some of it away," he said, explaining how the market price of bison meat could otherwise make it too expensive for local tribal people, many of whom live in poverty.

A Midwestern zoo has bought bison meat from Tribal Community Bison, they are now selling hot dogs, burgers, and steaks. Joe explained:

> They are really interested in the story line of the buffalo….(to) tell the people about buffalo and the Native Americans.

The marketing of non-meat products was also discussed.

> We try to do something with the hide…and the bones…we are still looking for ways to sell or use that.

Ecotourism was mentioned as having potential for expansion and contributions to the continuing economic sustainability of the operation.

> (We would like to)…Get more organized tours out here. More ecotours, showing and sharing with people how to raise buffalo.

Joe explained a variety of collaborative research and education projects that had helped to support Tribal Community Bison financially. These included relationships with local tribal colleges and state universities, tribal wildlife departments, and even a zoo from a large city in the mid-western US.

> (We are)…always looking for outside contributors to the project…always collaborating with other people and organizations… (We)…Have had staff come out from other groups, had community members come out, had youth come out, parks and recreation come out (to see and work with the bison)…

These collaborative activities have led to new opportunities for Joe, too.

> Being with the buffalo I have gotten to go a lot of places that I wouldn't have been able to go and met a lot of different people that I wouldn't have gotten to meet if it wasn't for the buffalo.
> It's been good…the collaboration and the people getting involved.
>
> It will be great for tourism…for more research.

Another of the operation's 'economic' goals was to bring more bison meat into the diet of the local people and tribal members. The meat, which is low in fat and cholesterol and highly nutritious, could help improve the health of the people, who suffer from high rates of heart disease and diabetes.

> It is a really nutritional food…Slowly we are getting the nutrition back in…(We hope to)…get the buffalo meat back into the diets of the people through the diabetes program, make it available for more people and make it affordable for people so they can buy it.

Whether discussing management approaches, economics or environmental issues associated with the sustainability of bison re-introduction by American Indians, Joe related almost every point back to his culture. These perspectives are further explored in the results of Research Question 2, presented below.

Research Objective Two:

To explore the role of American Indian culture in the management of bison for sustainability.

Culture

Cultural considerations were important in the management of bison for sustainability in Tribal Community Bison. In fact, they were a primary motivation for the establishment of the community based herd. "Culturally, it fit," explained Joe, describing his reasons for being involved in the project.

Joe discussed in detail how the culture impacted management. For Joe, culture was the basis for the respect shown the animal and the natural environment. Culture also underscored the lack of emphasis on herd profitability, and provided the impetus for reintroduction of bison meat into the diets of local tribal members.

Joe explained specific examples of how culture influenced herd management. For example, cultural protocols were especially important when it was time to harvest animals.

> I don't want to have to put them in a trailer and take them to a processing plant…Get them all stressed out and have to kill them. When we do have to kill, we want to do it with a prayer, and do it instantly…so they don't suffer. We try to do a prayer for them before and after they are killed…Treat…them good.

This respectful, culturally-based approach to harvest has led to interest in a mobile bison slaughtering plant that would allow for field harvest of the animals.

> Right now we are looking at this mobile slaughter unit. So we will be able to bring it into our pasture or wherever they are grazing and take some buffalo down. Field dress it and have hanging carcass there versus having to round them up and put them on a trailer and take them to a sale or slaughter house. I don't want to do that. (It causes)…Too much stress and it is hard on the animal and it is expensive…it could be done but (I will not do it) because of the respect (for) the animal.

Tribal Community Bison also utilized buffalo from their herd for cultural purposes. The buffalo pasture now serves as the site of a Sundance, the most sacred of Lakota ceremonies.

> …(The) Sundance grounds (are) in the buffalo pasture. My brother-in-law wanted to have a Sundance grounds. Its kind of right to have a Sundance grounds here and part of the buffalo. To me it is right, because the buffalo are a big part of the Sundance. Most all the ceremony has a lot to do with buffalo and it just falls into place. I didn't plan it that way, but that is how it came to be. They bring their ceremonies and here it is.

He went on to explain how some meat and bison skulls were used for ceremonial and/or spiritual uses. "We mostly have it for cultural activities," he said.

For Joe, working with the bison has been a way for him to personally reconnect with important aspects of his Lakota culture.

> …Just coming back into raising buffalo…I am fortunate to be able to do that and having a brother-in- law that really knows about the history, culture and ceremony parts of the buffalo, so I am getting to know more about that and the part they played in our culture. I am finding out more and more as I am around them and the people that know a lot about them.

Joe believed that sharing the buffalo culture was an important objective for his operation.

> One goal is to share, especially with Native people…what I have experienced …and put it together for people to understand it (the culture and the story)…to learn more and share more…

While Joe wanted to share the bison with both Natives and non-Natives, he was particularly interested in passing on the knowledge of the animals and culture to tribal youth. He discussed the possibility of developing a bison management curriculum for youth. This approach, of passing on knowledge to the next generation, provides another perspective on the sustainability of management approaches.

> I think it (sharing the buffalo culture) is good, and one of the things I am really interested in. For example…I would like to put together a little presentation for …students, and show them what the animal is and what they mean to the Lakota.
>
> I think it is real important we share the buffalo and the culture. Especially with the youth here…some kids haven't even seen a buffalo up close…all they know is beef cattle…

Joe described how the cultural aspects of the project provided him with some of his greatest sources of pride and achievement in herd management.

> What I am really happy about is the impact I had on the cultural side...Having the buffalo here for the ceremony and having access to the buffalo…The spiritual parts of it are back and we now have buffalo…Just the cultural aspects have been good.

Two additional themes emerged from the interviews with the manager for Tribal Community Bison. Most strongly related to the research question regarding the role of

culture was the theme of the importance of family connections to the bison. Joe described how his sister was most influential in getting him involved in the project initially, and how his brother-in-law had also been active in the work, teaching him and others in the community more about the Lakota stories, songs, ceremonies and spiritual beliefs associated with bison culture. In fact, he explained Tribal Community Bison's buffalo pasture, was part of his grandfather's homestead.

> This is the old homestead…my grandfather grew up here…and my father kinda grew up here…then it was kind of traded off…but there are still some family and extended family that have small parts of land…but…we were able to get it…so its kinda interesting that it was part of the family…

The final theme that was repeatedly stressed by Joe was a desire to continue learning about the buffalo, management, culture and the environment. He admitted to sometimes not knowing how to adequately evaluate the condition of his land and animals.

> I am still learning. I am interested in the grass, the water, and the nutrition of the animals. As far as the management, I am still learning…I try to learn about the grass and nutrition. I try to talk with other producers to try to find out what they give them…if I need to supplement them with salt and mineral and hay…I am really looking at talking to people about giving them grain and that is different from cattle because their nutritional needs are different.

Underscoring this need to learn more and become better informed, Joe acknowledged that one of the barriers to the success of his herd was his own lack of knowledge or experience in bison management.

> I think…one of the biggest barriers for myself is probably (not knowing) more specifics on the management and what needs to be done. Poor planning…we need better planning.

Joe highlighted planning as a critical need for the future of Tribal Community Bison.

> …Plan better to work with more people and have more people involved. Planning and plan well, the areas of the financing and other project (activities)…and stuff will come into place if you plan well.

Regarding buffalo's interaction with the environment, Joe pointed to a lack of readily available information or baseline data on the condition of reservation rangelands.

> I really don't know…how to gauge it…because I really don't have any real information on what it was like before.

Joe expressed an openness and support of bison research. His interests in buffalo were broad in scope.

> I want to study the buffalo more. Their habitat and social order…their grazing…fencing…the nutrition of their meat…

Similarly, he expressed a hope to continue learning about the songs and stories that are part of the Lakota/bison culture.

> …(Now) it is just like (we are) scratching the surface…(of the cultural knowledge)…

This desire to keep learning was critical to the herd manager's vision for the future of his community's operation. "We want to learn more and share more," he said.

Joe's perspective on the future of Tribal Community Bison was hopeful and realistic. He was encouraged by his community's response to his work.

> It is real new and so we are in a slow process. Just yesterday me and another community member went to find the buffalo there and tried to bring them back. I think it is really interesting because the young man that helped me was about 15 or 16 and he wanted to be right with the buffalo.
>
> I think it is going to have a real positive effect on the people and community. Slowly we are getting the nutrition back and they are able to see them.
>
> People are eating healthier… we now have the buffalo to eat because before that wasn't the case and we had to eat beef….So overall we have the cultural aspects and the spiritual aspects, the environmental aspects and people are learning about them. (People are)…better aware of their surroundings and what it all means…having the buffalo here for the community and having access to the buffalo meat and having access to the pasture to see the buffalo.

Joe reflected on the cultural and historical significance of the herd.

> It really has a big impact and I think the community is really interested and people have supported it and continue to support it. (It can be)…how it was a long time ago when we had our own land and our own meat and could provide for our family. Because…it was our food and clothing and shelter and it can be again.
>
> They are good, but they are also a challenge, you have to change your way of thinking about them. You think you are going to control them but you aren't. It is a challenge but it is a good challenge.

Research Objective Three

To investigate rangeland criteria that could be used to measure sustainability of bison reintroduction by American Indians.

The rangeland criteria were compared with equivalent measures from other studies at similar locations, as reported in the literature. Gelderman and Gerwing (2005)

summarized soil test results for samples from South Dakota analyzed during 2003-2004. The "West River" region, which included all of our study sites, represented 7%, approximately 500 samples, in the summary and was used as a basis for comparison to our analyses of baseline data for sustainability criteria.

Gelderman and Gerwing (2005) rank soil organic matter concentrations from 21 to 30 g kg^{-1} in the low range for soils sampled in South Dakota, concentrations from 31 to 40 g kg^{-1} in the medium range, and concentrations from 41 to 50 g kg^{-1} in the high range. At Research Site 1, organic matter ranged from high to low with values of 43 g kg^{-1} in the toe slope, 27 g kg^{-1} in the shoulder slope and 31 g kg^{-1} in the mid-slope positions (Table 4.1). With the steepness of this range site, erosion from the shoulder slope and decline in organic matter would be expected.

Aggregate stability is dependent on both internal (soil texture, organic matter content and Ca, Na concentration) and external (tillage, grazing, crop rotation) factors. Gollany et al. (1991) found that organic carbon, antecedent water content, and clay content influenced the aggregate stability of a clay loam soil in South Dakota. At Research Site 1, soil texture was medium for all treatments. Soil aggregates formed under perennial grasses were stronger than those formed under cultivated crops in the state (Eynard et al., 2004) and at the 20 cm depth ranged from 950 to 970 g kg^{-1}. Haynes and Swift (1990) also reported a higher resistance to slaking in pastures than tilled soils. The aggregate stability at Research Site 1 ranged from 919 to 951 g kg^{-1} (Table 4.1) and was lowest in the ungrazed treatment. The NRCS (USDA 2001a) reported in their Rangeland Soil Quality Information Sheet on Aggregate Stability that grazing can have

both positive and negative impacts on aggregate stability. Grazing may result in the destruction of surface aggregates and loss due to erosion, but it may also incorporate litter in to the soil which helps to build organic matter and hence soil structure. In this study, the high percentages for aggregate stability, without high clay content, may also be attributed to the diversity of species in rangelands, which provide varied root parameters contributing to stability (Graham et al., 1995; Gijsman and Thomas, 1995; Chan and Heenan, 1996).

The results for water content followed trends in soil organic matter and supported conclusions of the SSR that organic matter could be used as an indicator to describe water infiltration and water content in soils. The soil water content was 160 $g\ kg^{-1}$ in the toe slope compared to 100 $g\ kg^{-1}$ at the shoulder slope. Differences between mid-slope and toe or shoulder slope positions were not statistically significant. The USDA NRCS (1998) list a typical range of available water as 100-150 $g\ kg^{-1}$ for loamy sands and sandy loams and a range of 100-200 $g\ kg^{-1}$ for silty clay and clay. The soils at Research Site 1 were medium textured, sandy loams and fall in the typical ranges reported by the NRCS.

Table 4.1 Soil quality variables as influenced by slope position and grazing at Site 1

		Soil Quality Variables[1]		
Slope Position	Grazed	OM[2]	AS[3]	Water[4]
		g kg^{-1}	g kg^{-1}	G kg^{-1}
Shoulder	yes	2 7	939	100
Mid-slope	yes	31	941	130
Mid-slope	no	31	919	123
Toe	yes	43	951	160
Pr>F		0.0001	0.0505	0.0303
$LSD_{.05}$		4.3	22.4	37.6

[1]Soil quality samples were collected at the 0-20cm depth in May of 2003 and2004.
[2]OM = Soil organic matter
[3]AS = Aggregate stability
[4]Water = Gravimetric soil water

Plant available, soil nutrient analyses were completed for nitrate-N, phosphorus and potassium (Table 4.2). Nitrate-N showed trends similar to organic matter and was significantly higher in the toe slope position (10.8 mg kg^{-1}) than the shoulder position (6.0 mg kg^{-1}). Gelderman and Gerwing (2005) reported mean concentrations of 3.6 mg kg^{-1} for grass producing areas in SD.

Phosphorus was significantly higher in the toe slope position (7.3 mg kg^{-1}) than the other slope positions and grazing treatments. Toe slope P concentrations fell within the "medium" category for plant availability, however the other positions fell in the "very low" category. According to Gelderman and Gerwing (2005), 37 % of all West River soil samples fell within the low and very low categories. These un-cropped areas seldom receive P fertilizer applications and rely on organic matter release of phosphorus for range plant growth.

Potassium concentrations were not significantly different due to slope position or grazing treatment (Table 4.2). Potassium was in the very high category, as were 97 % of West River soils analyzed in 2003-2004. Soils are typically high in potassium due to the parent material in this region.

Soil pH and soluble salts (electrical conductivity) were also analyzed as factors which could potentially limit plant growth (Table 4.2). The soil pH at Site 1 was significantly higher in the shoulder position than the other slope positions and grazing treatments but none of the pH values would be considered limiting for plant growth. Average West River pH is 7.02 with all positions at Research Site 1 being slightly less than that. Electrical conductivity ranged from 0.21 to 0.28 mmho cm^{-1}, but was not significantly different due to slope position or grazing treatment and was in the "very low" category. Ninety seven percent of West River samples analyzed for soluble salts were within the "very low" category in 2003-2004. Average electrical conductivity for soil sampled in the same region was 0.76 mmho cm^{-1}. Values below 3.0 mmho cm^{-1} present little problem for plant growth.

Table 4.2 Soil chemistry variables as influenced by slope position and grazing at Site 1.

		Soil Chemistry Variables[1]				
Slope Position	Grazed	NO_3-N	Olsen P	K	pH	Salts
		mg kg^{-1}	mg kg^{-1}	mg kg^{-1}		mmho cm^{-1}
Shoulder	Yes	6.0	2.7	556.3	6.8	0.28
Mid-slope	Yes	7.3	3.0	582.5	6.4	0.21
Mid-slope	No	7.4	2.8	559.5	6.4	0.25
Toe	Yes	10.8	7.3	607.3	6.3	0.25
Pr>F		0.0482	0.0001	0.1625	0.0032	0.0597
LSD $P>_{.05}$		3.43	1.66	NS	0.21	NS

[1]Soil quality samples were collected at the 0-20 cm depth in May of 2003 and 2004.

Dry matter production was used as an indicator of plant productivity. Dry matter production was not significantly different among slope positions or grazing treatments at Site 1 (Table 4.3). Dry matter production ranged from 1261 to 1881 kg ha^{-1}. Larson and Whitman (1942) compared herbage production in moderately grazed (1838 kg ha^{-1}) and ungrazed sites (2650 kg ha^{-1}) in South Dakota and found a 44% difference. In the study by Sims, et al. (1978), in South Dakota, the dry matter production was 2330 kg ha^{-1} for ungrazed and 1180 kg ha^{-1} for grazed (50% difference). In our study there was a 30% difference between grazed and ungrazed treatments. Lacey and Van Poollen (1981) found differences in forage production with grazing, and (McNaughton, 1995) found that grazing in the Serengeti increased the rate of forage production, improved forage quality and increased plant species diversity. Forage production response to grazing can be dependent on many variables such as climate, stocking level, composition of vegetation and its resistance to grazing, as well as many other factors (Holechek et al., 2004).

Our forage quality measures included estimates of crude protein and fiber. Generally we assume that the higher the crude protein, the better the forage quality (Pinkerton, 1997). However, if energy is lacking in the diet, additional protein will not adequately compensate for it. Neutral detergent fiber is an estimate of the amount of cell wall material in a plant. Acid detergent fiber is an estimate of the cell wall, minus hemicellulose (ADF is a portion of NDF). The plant cell wall materials are usually considered to be indigestible, so the lower the NDF and ADF values the better. A typical analysis for alfalfa would be 310 g kg^{-1} ADF and 180 g kg^{-1} crude protein.

Crude protein concentrations at Site 1 ranged from 61 to 68 g kg^{-1}. Acid detergent fiber concentrations ranged from 459 to 477 g kg^{-1} and NDF concentrations ranged from 670 to 701 g kg^{-1}. There were no differences in crude protein, acid detergent fiber, or neutral detergent fiber due to slope positions or grazing treatments (Table 4.3). Jurgens (1996) in his "Animal Feeding and Nutrition" publication reported that the typical concentration of crude protein in sun cured hay from the Midwest was 60 g kg^{-1}. Severson (1982) reported crude protein concentrations of 70, 90, and 80 g kg^{-1} for grasses, forbs, and shrubs from range sites in the Black Hills of SD. In Severson's study, acid detergent fiber concentrations were 440, 360, and 320 g kg^{-1} for grasses, forbs and shrubs respectively. Our results show similar concentrations.

Table 4.3 Plant variables as influenced by slope position and grazing at Site 1

		Plant Variables[1]			
Slope Position	Grazed	CP[2]	ADF[3]	NDF[4]	DMP[5]
		g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}
Shoulder	yes	65	459	670	1261
Mid-slope	yes	66	477	701	1310
Mid-slope	no	61	471	692	1881
Toe	yes	68	464	681	1628
Pr>F		0.6228	. 7788	0.7476	0.1078
LSD $P>_{.05}$		NS	NS	NS	NS

[1]Plant samples were collected at peak standing crop in July of 2003 and 2004.
[2] CP = Crude Protein
[3] ACF = Acid Detergent Fiber
[4]NDF = Neutral Detergent Fiber
[5] DMP = Dry Matter Production

Table 4.4 includes the plant species inventory for Research Site 1, dividing the species into groups of grass and grass-like, forb, and woody. The common name, scientific name, and Lakota name (if known)are listed. At Site 1 the inventory included 19 species in the grass and grass-like category, 59 species in the forb category, and five species in the woody categories. In total, 83 species were found. The plant diversity of rangelands supports sustainability by providing resilience to disturbance (fire and grazing) and promoting the cycling of nutrients and energy (Sayre, 2001). Sims et al. (1978) found 54 plant species in a similar mixed-grass prairie site. They also found 3 to 4 times more forb species than grass species. Collins et al. (1998) measured species richness (number of species in 50 m^2) in grazed and ungrazed ranges in the Konza Prairie in Kansas. They reported 64 species in grazed areas compared to 46 in ungrazed. In the grazed areas there were 18 grass, 41 forb and 5 woody species. In the ungrazed areas there were 13 grass, 29 forb and 4 woody species. In this study, 23% of the species were

grass and in the Konza Prairie study, 28% of species were grass, regardless of grazing treatment.

Studies in Colorado reported that 89-94% of the forage selected by bison was grass (Peden et al., 1974; Kautz and Van Dyne, 1978). Forbs were 5-6% of the selection and shrubs 1-4%. Most research indicates that bison select a higher proportion of grasses than do cattle, however there may be considerable variation with season and availability (Holechek et al., 2004).

Table 4.4 Plant species identified at Research Site 1.

Common Name	Scientific Name	Lakota Name
Grass and grass-like:		
Little bluestem	*Schizachyrium scoparium*	Peji Sasa Swula
Big bluestem	*Andropogon gerardii*	Peji Sasa Okihe Tankinkinyan
Blue grama	*Bouteloua gracilis*	Peji Okijata
Buffalograss	*Buchloe dactyloides*	Peji' Iwi'cakoyaka
Green needlegrass	*Stipa viridula*	
Hairy grama	*Bouteloua hirsuta*	
Japanese brome	*Bromus japonicus*	
Kentucky bluegrass	*Poa pratensis*	Peji Blaskaska
Needleandthread	*Stipa comata*	
Prairie junegrass	*Koeleria macrantha*	
Red threeawn	*Aristida purpurea*	Peji Takan Kaza
Reed canarygrass	*Phalaris arundinacea*	
Sedge (all)	*Cyperacae spp.*	Psin tanka
Sedge, Nebraska	*Carex nebrascensis*	
Sideoats grama	*Bouteloua curtipendula*	Wapaha Kimnimnila Peji
Sixweek fescue	*Vulpia octoflora*	
Smallwing sedge	*Carex microptera*	
Switchgrass	*Panicum virgatum*	
Western wheatgrass	*Pascopyrum smithii*	Pejihcaka
Downy brome	*Bromus tectorum*	

Table 4.4 continued

Common Name	Scientific Name	Lakota Name
Forb:		
American vetch	*Vicia americana*	Tasusu
Slender beardtongue	*Penstemon gracilis*	On hunka lowanpi iyececa
Candle anemone	*Anemone cylindrica*	
Cutleaf ironplant	*Haplopappus spinulosus*	Wahcaziwastemna
Daisy fleabane	*Erigeron strigosus*	
Dotted gayfeather	*Liatris punctata*	Tate Cannuga
Easter daisy	*Townsendia exscapa*	
False gromwell	*Onosmodium molle*	
False indigo	*Amorpha fruticosa*	Zintkalatacan
Flodman's thistle	*Cirsium flodmanii*	
Goatsbeard(salsify)	*Tragopogon dubius*	
Giant goldenrod	*Solidago gigantea*	
Canada goldenrod	*Solidago canadensis*	Wahca ziblu
Soft goldenrod	*Solidago mollis*	
Stiff goldenrod	*Solidago rigida*	Canhlogan maka ayublaya
Groundcherry	*Solanaceae spp.*	
Groundplum milkvetch	*Astragalus crassicarpus*	Pte Tawate
Heath aster	*Aster ericoides*	Wahcazi Waste
Lanceleaf bluebell	*Mertensia lanceolata*	
Low larkspur	*Delphinium bicolor*	
Slender milkvetch	*Astragalus gracilis*	Pejuta Skuya
Standing milkvetch	*Astragalus adsurgens*	
Ox-eye	*Heliopsis helianthoides*	
Common pepperweed	*Lepidium densiflorum*	
Poison ivy	*Toxicodendron rydbergii*	Wikoska Tapejuta
Prairie coneflower	*Ratibida columnifera*	Asanpi Iyatke
Pricklypear cacti	*Opuntia spp.*	Unhcela Blaska
Purple coneflower	*Echinacea angustifolia*	Icahpe hu
Purple prairie clover	*Dalea purpurea*	
Pussytoe	*Antennaria spp.*	Canhlogan hu wanjila
Small leaf pussytoe	*Antennaria parvifolia*	
Rush skeletonplant	*Lygodesmia juncea*	Canhlogan Hu Can Swula Un He Tuktektel Yuke
Cudweed sagewort	*Artemisia ludoviciana*	Peji hota ape blaskaska
Fringed sagewort	*Artemisia frigida*	Peji Hota Wastemna
Green sagewort	*Artemisia dracunculus*	Canhlogan Wastemna
Scarlet gaura	*Gaura coccinea*	On Sunk Oyuspapi
Scarlet globemallow	*Sphaeralcea coccinea*	Heyoka Tapejuta

Table 4.4 Continued

Common Name	Scientific Name	Lakota Name
Forb continued:		
Scribner (panicum)	*Dichanthelium oligosanthes var. scribnerianum*	
Breadroot scurfpea	*Psoralea esculenta*	Tinpsila
Lemon scurfpea (slimleaf)	*Psoralea lanceolata*	
Silverflower scurfpea	*Psoralea agrophylla*	Mato tatinpsila
Slimflower scurfpea	*Psoralea tenuiflora*	Wahpe peji
Shell-leaf penstemon	*Penstemon grandiflorus*	
Slender leaf collomia	*Collomia linearis*	
Smooth blue aster	*Aster laevis*	
Stiff sunflower	*Helianthus rigidus*	Wahcazi Tanka
Tall cinquefoil	*Potentilla arguta*	
Violet	*Violaceae spp.*	
Western ragweed	*Ambrosia psilostachya*	Canhlogan Wastemna
Western wallflower	*Erysimum asperum*	Canhlogan Pa
Western Yarrow	*Achillea millefolium*	Hante canhlogan
White milkwort	*Polygala alba*	
Wild lettuce	*Lactuca serroila*	Wahpe inkpa jiji
Wild licorice (American)	*Glycyrrhiza lepidota*	Wanawizi Cikala
Woolly cinquefoil	*Potentilla hippiana*	
Woolly plantain	*Plantago patagonica*	
Woolly vervain	*Verbena stricta*	To Pestola
Yellow evening primrose	*Calylophus serrulatus*	Wahcazi Cikala
Yucca	*Yucca glauca*	Hupestola
Woody:		
Leadplant	*Amorpha canescens*	Zitka Tacan
Skunkbrush	*Rhus aromatica*	Canunkcemna
Western Snowberry	*Symphoricarpos occidentalis*	Oh sunk nasapi hu
Wild rose	*Rosaceae spp.*	Onjinjintka Hu
Ponderosa Pine	*Pinus ponderosa*	Wazi Can
Others:		
Lichen		Can Wiziye
Puffball		Hoksi Cekpa

(Rogers, 1920) and (Johnson and Larson, 1999)

Chapter 5. Results and Discussion for Case Study II – Tiospaye Bison

Introduction

Case Study II, Tiospaye Bison, was individually-managed and was located within a 1000 ha range unit that had been lightly stocked since December of 2000. The pasture had several live springs and one well. The pasture was leased through the Bureau of Indian Affairs (BIA) with large areas of family-owned allotments within the lease. Stocking rate is set by BIA regulations for the area which is typically 40 acres per Animal Unit Month (AUM). The fencing of the entire pasture was primarily a 1.2 to 2.0 m fence that was five strands of barbwire and one strand of electric fence. There was a small holding corral in the pasture near the spring.

The bison operation was started from efforts of one family that wanted to bring back the bison to the area due to the cultural connection they felt toward the bison. In Lakota culture, the family concept includes extended family members such as cousins, aunts and uncles as well as brothers, sisters and grandparents. The Lakota word for extended family is tiospaye. The family in Case Study II included a large extended family that developed the bison operation. The original bison were obtained through a share crop agreement with the local tribal bison program.

The management style was mostly a hands–off approach with a summer and winter rotational system that divided the pasture into two smaller pastures. There was minimal supplement feeding done except during extreme weather conditions or during calving season to supplement the cows. Vaccinations were done in the first several years of ownership, but due to lack of an adequate corral and handling system, vaccination was

discontinued. There was no disease testing done. The herd manager was very interested in cultural connections between bison and tribal people and in using the by-products (e.g. hide, fur, skulls, etc.) for local artists. The major challenges for the project were fencing issues, lack of corral and adequate handling facilities, finances, and securing a marketing outlet. The operation was primarily financed and supported through hunts, local meat sales, trading bison meat and by- products, and by local volunteers assisting with herd labor and management.

Background

A face-to-face, in-depth interview was conducted with 'Jim', the bison manager and owner of Tiospaye Bison during fall, 2007. Jim, an enrolled tribal member, saw his experience as a cultural journey and wanted to see if he could develop a bison herd.

Jim and his family felt a spiritual connection toward reintroducing thee bison. Jim explained his motivation to become involved.

> …Something told me to do it, maybe a dream, maybe someone, but something happened…sort of a spiritual connection…
>
> Getting to know the animals and finding that connection…

The animals were obtained through a crop share agreement with the Oglala Sioux Parks and Recreation Authority.

> This was a test for me "*Igulta*" in Lakota, which means to challenge yourself.

There was also a need to have others to help and challenge themselves in the process.

> My Fathers and Grandfathers were telling me to do something. They would tell me stories about the winter count and how the buffalo were lost and killed.
>
> …So when I was 24…, I started going through all the ceremonies and started to figure out what I wanted to do with my life, but didn't start doing anything (with the buffalo) until 1992.

Responses to interview questions for Tiospaye Bison are presented and discussed according to the research objectives below.

Research Objective One:

To identify management practices associated with sustainability of bison introduction by American Indians.

Management practices associated with sustainability were explored through a series of questions regarding overall management, land, and ecological and economic issues.

Overall herd management

The topics discussed in the overall management of the Tiospaye Bison focused on the day-to-day activities of the herd manager.

Fencing and corral systems were an on-going theme in Jim's discussion of herd management. Jim described a typical year with Tiospaye Bison. During the winter months, Jim would check the gates and check the fences at least twice a week after work.

> During the week, I checked the fence in the pick up, but sometimes on the weekend I checked the fence on horseback and took my wire stretcher… there were no phones then so I had to take everything with me to fix fence.

Regarding winter feeding, Jim said his bison were 'caked' twice per week during the cold, during big snow storms and during calving season. The 'cake' is a protein based supplement that comes in bite-sized cubes. These cubes were scattered on the ground and provided the bison with increased nutrition. Occasionally, he would give his herd a bale of alfalfa or hay "just for a treat.". In the spring, Jim felt a " … certain amount of pride when the calves started coming." He also shared that every year, Tribal Community Bison lost one or two calves. During this season, the bulls went their separate ways. Occasionally, Jim would feed them to entice them to come around.

The summer months were a time to "watch them grow." This was also the season when Jim began getting requests for meat.

In the fall, Jim would decide which bull would be taken down for processing. He expressed his awareness of the importance in keeping certain bulls for breeding. Jim discussed his need for corrals. He described how his lack of an adequate corral system impacted his management. For example veterinarians were not brought to the herd if an animal was sick or injured because there were not adequate handling facilities to allow for veterinary care.

> During the first few years I vaccinated them and then I didn't after that because I didn't have good enough corrals.
>
> Sometimes animals would get hurt, but I had no way of doing anything about it….sometimes I had to put one down.

In addition to not vaccinating, Jim also did not do any weaning, tagging or branding.

Jim was concerned about his herd's nutrition, and whether or not what he was feeding them was adequate. He expressed a desire to do what he needed to keep them healthy. He talked extensively about the amount of protein, alfalfa and other supplements fed to his animals.

Jim also discussed the human dimension of herd management. He described how there were happy moments that only his family and he would experience, such as watching the buffalo play with a bale of hay that he had put out in the pasture for them. There were also more somber times…

> We would hunt one or two out. It was an emotional thing when we took some down…my heart was sad… the buffalo wouldn't come back to that spot for a time (after the kill).

Day-to-day herd management was discussed in terms of dollars. Jim described how keeping the herd was at times a financial challenge. He said, "I had to ration out my gas, my expense of my car parts and my four wheel drive."

Jim's range management plan that included splitting his pasture into two sections. He made management decisions by talking to the tribal park's herd manager, and about their management of the tribe's bison herd. Due to drought conditions, fencing and the animals getting out became an issue. At times herd management was stressful. He said, "We had a drought and I didn't know what to do…"

Jim also discussed the dynamics of his herd. He described how after the herd began to grow, the herd split off into two different groups. Due to health issues, about five years into the project, he decided to minimize his work load by giving a large number of his animals back to the tribal park's program for a crop share agreement; also

some animals were sorted off for culling. At this time, the animals had to be rounded up, sorted and trucked back to the tribal herd or were sold to a local packing house. This was an emotional time due to the stress of moving the animals and having to sell some of the herd.

> At the time of the round up they (the buffalo) lost a lot of weight and would circle in the corral. I did have them trained to follow me by shaking a can of grain…

Economics and environmental issues played an important role in Jim's decision to sell animals and when to sell them.

Environmental sustainability

Jim expressed concern for the environment in spiritual terms and referred to stories he had heard as a small boy growing up on the land. Water and grass were primary ecological concerns. He also discussed the quality of the land and the large ecosystem where his herd was located. A representative from the tribal parks program told Jim about the land as beautiful, prime buffalo country.

> I didn't realize how special the land was...and I am really thinking about bringing in a beaver or two…There always seems to be good grass in there.

He described up to twelve live springs and a creek running through the pasture and this seemed to be an excellent place for bison.

Jim explained that families wanting to move back on to their land disrupted the herd management and the environment to some degree. Due to the fact that the individual producer was leasing tribal and allotted land, people building homes on the

buffalo pasture became an issue throughout the duration of the project. People could acquire a few acres of tribal land to build houses or could acquire their allotted land to build houses on Jim's buffalo pasture. This impacted herd and pasture management.

> …People moving back on their land disrupted things, but it is really understandable (to move back on to their land), but some of them didn't understand and would say "Your have buffalo up there? Are they mean? Will they hurt me?" I told them just not to mind them (the buffalo) as long as their dogs don't chase them, that gets the old cows mad…

The drought was a recurring theme throughout the interview. Jim described how the quality of this pasture declined under drought conditions. The creek mentioned earlier, slowed to a "trickle" during the drought.

> It was good in the beginning…but… (when) we were going through the drought and in the end I was trying to buy feed and grain so the drought kind of hurt me.

Water within the pasture, Bureau of Indian Affairs (BIA) regulations and policies, and an Environmental Quality Impact program (EQIP) through the Natural Resources Conservation Service were mentioned as protective factors for the land. The EQIP project allowed Jim to take part in a cost share program that partially paid for land improvements such as cross fencing and water developments. Jim also described his management approach to splitting the pasture into two pastures.

Economic sustainability

Jim found economic sustainability one of the most important issues related to the land and with the bison.

> It (financially) was tough…I just got by…day to day…But some how I survived, and good thing I had a job to help with it. I was busier than heck…

By-products, hunts and a barter system were used in combination to finance the project. Jim expressed how he:

> Sold some hunts, sold some meat for Sundances… I had a freezer full of meat all the time so people could buy rump, steaks, ribs or "taniga" or skulls or hides. I used the barter system. I would trade meat or by-products for work. I wanted to make some by-products and it was starting to work and it is working now. We have a local taxidermist, we have some local drum workers, lot of people are into arts and crafts. The by-products are there and the meat is too…
>
> …Every time I made a sale, every animal, the majority I took to the bank to make the lease payment.

Jim also donated some of this bison for local community feasts and Sundances.

He described how marketing became more of a challenge as his herd grew, and the market for buffalo declined.

> …I needed some type of marketing or some type of institution or something to help…. Some type of infusion of money to help me to market animals. I had a lot of people…(all they) wanted to give me was $250 (per head)…I had to take whatever was handed me. Buffalo prices were really low at that time and I couldn't get them sold for anything. The money wasn't there.
>
> If I would have had a marketing plan in place and the equipment in place it might have been different.

Initially, a local tribal micro-lending agency provided funding for Jim to build his first fences and establish his herd. He had also hoped to secure funds for a four-wheeler and corral panels. However, when the buffalo market declined, this support also deteriorated. Financing the land leases (rates doubled in five years), fencing and feed proved difficult. Jim said:

> Maybe if the economic conditions on the reservation weren't so difficult (he would have been more successful).
>
> I tried to find a chance and I went to all the local banks, from the Nebraska side to the interstate, (to) Fort Pierre to see if they would give me some type of loan or something, cuz (sp) I had all these animals. (They said they) 'can't give me a loan unless I sold some' but I didn't have the equipment to get them out of there to sell them. They wouldn't do it. I refinanced for several years and then politically it was pulled out from under me. The buffalo market was down and they (the banks) wouldn't help me.

One of Jim's reasons for selling a large part of the herd five years into the project was economic. Financing the herd through loans compromised the economic viability of the operation. Later, due to economics of trying to maintain the fence and personal, health-related issues, Jim "lost" his herd after they got out of the pasture. There is an on-going investigation of someone stealing the animals and some of the animals being shot.

It had not occurred to Jim to expand the herd.

> Right now, I just want to balance the budget, re-establish our credit. I am getting to the point now in six months, I'll be debt free.

Still Jim remained optimistic about the future of bison.

> Maybe one day I'll see a big return. The by-products are there and the meat is there too. People don't realize it but they are eating meat at every celebration. Economically, people are starting to try it.

For Jim, the cultural dimension was intertwined with all the other aspects of his bison herd and everything that was accomplished through his efforts. These perspectives are further explored in the results of Research Question 2, presented below.

Research Objective Two:

To explore the role of American Indian culture in the management of bison for sustainability.

Culture

Cultural considerations were important in the management of Tiospaye Bison. Sharing the culture was a primary motive for the manager to establish a bison herd in the first place. What motivated Jim to become involved in bison production?

> (It was) just an opportunity to see why and from my heart and something told me to do it, maybe a dream, may be someone, but something happened. Sort of a spiritual connection, but in my heart I had to try it and go with it. Other than that…getting to know the animals, and finding the connection…
>
> Fathers and Grandfathers were telling me to do something and they would tell stories and they started telling me stories about the winter count and how the buffalo were lost and killed when it came down to it. I began to wonder what I was doing with my life. I felt I wasn't making any positive changes in my life (on) this reservation… so I started going through all the ceremonies and stuff.

All management decisions were made with consideration of the cultural importance of the bison. Jim used ceremonies as part of his approach to herd management and said, "…without that (the ceremonies), things wouldn't be as they are…whatever we did with the buffalo was culture…"

Jim and his family have been instrumental in bringing the Lakota Buffalo Dance back to his community and also to people world wide. He discussed his bison herd in the context of a large cultural renaissance on his reservation.

> We are finally learning what happened to us as a people. We are finally learning to live up to the expectations of some of these prayers…I am glad to be part of it.

In fact, Jim's work with his herd put him in a position of respect in his community.

> People look up to me every time there is a gathering and…think I need to give the prayer. . Connection to the symbol of our culture and it is…an honor…yet again. They look at me to say the prayer and I get this thought and…and the things that go through my mind that this prayer will help them with what ever goal they have.

With Jim as a provider of bison meat and one of the tribe's few buffalo dancers, he played an important role in the community.

> I gave some meat to the Sundance. At every Sundance there is a buffalo. We sing and we praise him. I make my offerings in that way, but giving this to them, the buffalo dance…

The primary goal was not only to bring back the buffalo and the buffalo dance, but also to share them. He discussed how he had reached out in the community.

> We have been invited to several different schools in the last year. People are asking questions about it and that is the message that young people need to hear.

Another cultural consideration for Jim was having bison meat in the diet of the people.

> Whatever we did with the buffalo was culture. The other 50% was mainly having meat available.
>
> People don't realize it, but they are starting to eat the meat at celebration…parks, Sundance, wake, funeral or any celebration. People don't realize it, but they are eating buffalo meat… People are starting to try it and I say without salt. Your body is going to thank you for that, you don't need salt or sugar with that (he laughs).

Utilization of bison by–products was also discussed. Jim described tribal art work as a mechanism for people to realize who they are and to discover their own identity.

The role of community and collaboration emerged as additional themes in discussion of Jim's bison herd. Positive aspects included support from the Tribal Parks Department. Jim began with a share-cropping arrangement and it took about five years to secure the land for his herd. Jim described the process as "…fun organizing it and getting to know and finding the people to help with it."

The park's biologist and herd manager were also valuable resources. The herd manager advised Jim to "let them be who they are, they will understand you after a time." In addition, the local tribal college assisted with education and research. The local tribal micro-lending agency was also helpful, as was an area banker, and programs through the USDA Natural Resources Conservation Service.

Community members sometimes volunteered to assist Jim with efforts such as fencing and round ups. Community members also participated in cultural ceremonies with Jim. "People came to see the cultural buffalo dance," he said.

However, the government programs and cost sharing requirements became problematic for Jim, and his relationship with lenders declined with the bison market. Community members also sometimes found it difficult to contribute their time and effort.

> I felt like I was by myself. Nobody wanted to work, nobody wanted to donate their time unless they got a piece of the action.

Sometimes they even undermined his effort by cutting fences allowing the bison to escape.

> They would eat the meat if it was free….(It was about)…survival. Some (tribal members) are having a hard, hard time.

Jim characterized this collaboration as '50% positive and 50% not so positive'. Jim also reached out to others.

> You have people coming into hunt and I welcome them. I want to be friends with them and we have people that want to come in to see what is going on.

Jim dealt with a chronic heart condition that required surgery during the project. He described how he used the herd as a reason to keep living, and give a broader purpose for his life.

> I think I wouldn't have come back (health issues). So I think there is some unfinished business I have to do. That is why I got better. So I think I need to do it (buffalo dance).

The learning process was another important theme reflected in Jim's comments. He described his own education about culture, land management, herd management and financial aspects. Jim said, "The biggest successes are to gain the knowledge." He spoke of the need for continued learning in these and other areas such as how to butcher. His advice for other tribal people who may be interested in getting involved in bison production.

> (He laughs) If your hearts not into it, don't do it; if your heart is there, then do it. That animal is tough and you have to be strong.
>
> I could probably write a book about it. (It takes) …land, equipment, collateral and the funding... and time to balance it all
>
> The old days are gone and we wanted to make friends with them (the bison) again.

Jim added:

> The strength and the spirit of the buffalo kept me alive today. So sometimes it is beyond words… You can't match that with any written

> document. It is there for the people and he gave his heart for them. Tunkasula gave that to the people. We have to learn with them.

Research Objective Three:

To investigate rangeland criteria that could be used to measure sustainability of bison reintroduction by American Indians.

The rangeland criteria were compared with equivalent measures from other studies at similar locations, as reported in the literature. Soil organic matter content at Site 2 (Table 5.1) was not significantly different between the toe and mid-slope positions. However, the shoulder position (29 g kg^{-1}) was significantly less than the mid-slope ungrazed (38 g kg^{-1}) and toe-slope position (38 g kg^{-1}). According to Gelderman and Gerwing (2005) these concentrations (except the shoulder position) are in the medium range for organic matter. At both Research Site 1 and Research Site 2, organic matter content was lowest on the shoulder slope, probably due to erosion of topsoils.

Aggregate stability ranged from 760 to 880 g kg^{-1} but significant differences due to slope position and grazing treatment were not found (Table 5.1). Eynard et al. (2004) reported grassland aggregate stabilities of 730 g kg^{-1} on SD ustoll and 810 g kg^{-1} on SD ustert soils sampled at the 0-20 cm depth and air dried. Soil texture was medium for all slope positions at Site 2.

Soil quality baseline data (Table 5.1) indicated that soil water content was greater in the mid-slope exclosure than the mid-slope grazed plots and shoulder position. Soil water content was also greater in the toe slope then in the mid slope grazed and shoulder slope. However there was no significant difference in water content between the mid-

slope ungrazed and toe slope. These results were similar to differences found for soil organic matter. Water content was in the normal range for medium textured soils.

Table 5.1 Soil quality variables as influenced by slope position and grazing at Site 2

		Soil Quality Variables[1]		
Slope Position	Grazed	OM[2]	AS[3]	Water[4]
		g kg^{-1}	g kg^{-1}	g kg^{-1}
Shoulder	yes	29	760	134
Mid-slope	yes	33	843	202
Mid-slope	no	38	856	252
Toe	yes	38	880	245
Pr>F		0.0095	0.1701	0.0001
$LSD_{.05}$		5.6	NS	31.2

[1]Soil quality samples were collected at the 0-20 cm depth in May of 2003 and 2004.
[2]OM = Soil organic matter
[3]AS = Aggregate stability
[4]Water = Gravimetric soil water

Nitrate-N concentrations (Table 5.2) at Site 2 were slightly higher than at Site 1, but no significant difference between slope position and grazing treatments was found. Concentrations ranged from 10.3 to 8.7 mg kg^{-1}, higher than concentration means reported by Gelderman and Gerwing (2005) of 3.6 mg kg^{-1} from grassland soils in SD.

Phosphorus was greater in the toe-slope position (6.0 mg kg^{-1}) than the shoulder and mid-slop grazed position, at the 0-20 cm depth (Table 5.2). There was no significant difference between the other positions. Phosphorus levels fell between the very low and low positions compared to other soils tested in the region.

At Research Site 2, potassium was lower in the shoulder position than the other positions and grazing treatments, but all plots were in the very high range (Table 5.2).

The majority of soil samples from West River SD contain very high concentrations of potassium due to the parent material and low precipitation levels.

Soil pH at Research Site 2 was higher in the shoulder position (7.5) than the other positions (Table 5.2). This pH value was also slightly higher than the average for soil in this same area, which is 6.8. All pH values were within a normal range to support prairie plant growth. Electrical conductivity ranged from 0.32 to 0.35 mmho cm^{-1} but was not significantly different between the slope positions or grazing treatments (Table 5.2). However, all positions were lower than the average soil test for the region which is 0.9 mmho cm^{-1}. High pH and soluble salts are frequently reported in arid climates. Electrical conductivities at Research Site 2 were in the very low category (Gelderman and Gerwing, 2005) and would not be limiting to range plant growth.

Table 5.2 Soil chemistry variables as influenced by slope position and grazing at Site 2.

		Soil Chemistry Variables[1]				
Slope Position	Grazed	NO_3-N	Olsen P	K	pH	Salts
		mg kg^{-1}	mg kg^{-1}	mg kg^{-1}		mmho cm^{-1}
Shoulder	yes	10.3	2.5	413.3	7.5	0.35
Mid-slope	yes	10.1	3.8	507.3	6.9	0.32
Mid-slope	no	8.7	4.2	549.8	6.8	0.33
Toe	yes	9.5	6.0	542.7	6.8	0.33
Pr>F		0.827	0.0165	0.0236	0.001	0.718
LSD $P>_{.05}$		NS	2.00	92.01	0.35	NS

[1]Soil quality samples were collected at the 0-20 cm depth in May of 2003 and 2004.

Plant dry matter production at Research Site 2 ranged from 908 to 1516 kg ha^{-1} but was not significantly different due to slope position or grazing treatment (Table 5.3). Production was limited by lack of precipitation, and was less than production reported at

Research Site 1 and by Larson and Whitman (1942) in South Dakota. There was a 40% difference between grazed and ungrazed treatments, more than reported at Research Site 1 (30%), but very close to the difference reported by Larson and Whitman (44%). In the study by Sims, et al. (1978), in South Dakota, the dry matter production was 2330 kg ha $^{-1}$ for ungrazed and 1180 kg ha $^{-1}$ for grazed (50% difference).

None of the forage quality measures at Research Site 2 were influenced by slope position or grazing treatment (Table 5.3). Crude protein concentrations ranged from 59 g kg^{-1} to 65 g kg^{-1}, very similar to those reported from Research Site 1 (61 to 68 g kg^{-1}). Acid detergent fiber concentrations ranged from 435 to 493 g kg^{-1}, very similar to the 459 to 477 g kg^{-1} range at Research Site 1. Neutral detergent fiber ranged from 618 to 725 g kg^{-1} and was lowest in the shoulder position.

Table 5.3. Plant variables as influenced by slope position and grazing at Site 2.

		Plant Variables[1]			
Slope Position	Grazed	CP[2]	ADF[3]	NDF[4]	DMP[5]
		g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}
Shoulder	Yes	65	435	618	967
Mid-slope	Yes	59	479	683	908
Mid-slope	No	59	493	725	1516
Toe	Yes	61	477	670	1428
Pr>F		0.837	0.2048	0.2752	0.0763
LSD P>$_{.05}$		NS	NS	NS	NS

[1]Plant variables were collected at peak standing crop in July of 2003 and 2004
[2] CP = Crude Protein
[3] ACF = Acid Detergent Fiber
[4]NDF = Neutral Detergent Fiber
[5] DMP = Dry Matter Production

Table 5.4. lists the plant species inventory for Research Site 2. The categories include grass and grass-like, forb, and woody. Seventeen species were found in the grass

and grasslike category, fifty nine in the forb category, and five in the woody category. These data are very similar to the results for Research Site 1. In total, 81 species were found at Site 2 compared to 83 species at Research Site 1. Sims et al. (1978) found 54 plant species in a similar mixed-grass prairie site. They also found 3 to 4 times more forb species than grass species. Species diversity has been found to enhance soil structure (Graham et al., 1995; Chan and Heenan, 1996), promote nutrient and energy cycling and provide resilience (Sayre, 2001). Each of these properties has been identified as necessary for "Rangeland Health" (Pyke et al., 2002) and criteria for sustainability.

Table 5.4. Plant species identified at Research Site 2.

Common Name	Scientific Name	Lakota Name
Grass and grass-like:		
Little bluestem	*Schizachyrium scoparium*	Peji Sasa Swula
Big bluestem	*Andropogon gerardii*	Peji Sasa Okihe Tankinkinyan
Blue grama	*Bouteloua gracilis*	Peji Okijata
Buffalograss	*Buchloe dactyloides*	Peji' Iwi'cakoyaka
Green needlegrass	*Stipa viridula*	
Blue grama	*Bouteloua hirsuta*	
Japanese brome	*Bromus japonicus*	
Kentucky bluegrass	*Poa pratensis*	Peji Blaskaska
Needleand thread grass	*Stipa comata*	
Prairie junegrass	*Koeleria macrantha*	
Red threeawn	*Aristida purpurea*	Peji Takan Kaza
Sedge (all)	*Carex spp.*	Psin tanka
Nebraska sedge	*Carex nebrascensis*	
Sideoats grama	*Bouteloua curtipendula*	Wapaha Kimnimnila Peji
Sixweek fescue	*Vulpia octoflora*	
Smallwing sedge	*Carex microptera*	
Western wheatgrass	*Pascopyrum smithii*	Pejihcaka
Downy Brome	*Bromus tectorum*	
Forb:		
American vetch	*Vicia americana*	Tasusu
Beardtongue, Slender	*Penstemon gracilis*	On hunka lowanpi iyececa
Candle anemone	*Anemone cylindria*	
Cutleaf ironplant	*Haplopappus spinulosus*	Wahcaziwastemna
Daisy fleabane	*Erigeron strigosus*	
Dotted gayfeather	*Liatris punctata*	Tate Cannuga
Easter daisy	*Townsendia exscapa*	
False gromwell	*Onosmodium molle*	
False indigo	*Amorpha fruticosa*	Zintkalatacan
Flodman's thistle	*Cirsium flodmanii*	
Goatsbeard	*Tragopogon dubius*	
Giant goldenrod	*Solidago gigantea*	
Canada goldenrod	*Solidago canadensis*	Wahca ziblu
Soft goldenrod	*Solidago mollis*	
Groundcherry	*Physalis virginiana*	
Groundplum milkvetch	*Astragalus crassicarpus*	Ptetawota

Table 5.4 Continued

Common Name	Scientific Name	Lakota Name
Forb continued		
Stiff goldenrod	*Solidago rigida*	Canhlogan maka ayublaya
Groundcherry	*Physalis virginiana*	
Groundplum milkvetch	*Astragalus crassicarpus*	Ptetawota
Heath aster	*Aster ericoides*	Wahcazi Waste
Lanceleaf bluebell	*Mertensia lanceolata*	
Low larkspur	*Delphinium bicolor*	
Slender milkvetch	*Astragalus gracilis*	Pejuta Skuya
Standing milkvetch	*Astragalus adsurgens*	
Oxeye	*Heliopsis helianthoides?*	
Pepperweed, common	*Lepidium densiflorum*	
Poison ivy	*Toxicodendron rydbergii*	Wikoska Tapejuta
Prairie coneflower	*Ratibida columnifera*	Asanpi Iyatke
Prairie sandreed	*Calamoviifa longifolia*	
Pricklypear cacti	*Opuntia spp.*	Unhcela Blaska
Purple coneflower	*Echinacea angustifolia*	Icahpe hu
Purple prairie clover	*Dalea purpurea*	
Pussytoe	*Antennaria spp.*	Canhlogan hu wanjila
Small-leaf pussytoe	*Antennaria parvifolia*	
Rush skeletonplant	*Lygodesmia juncea*	Canhlogan Hu Can Swula Un He Tuktektel Yuke
Cudweed sagewort	*Artemisia ludoviciana*	Peji hota ape blaskaska
Fringed sagewort	*Artemisia frigida*	Peji Hota Wastemna
Green sagewort	*Artemisia dracunculus.*	Canhlogan Wastemna
Scarlet gaura	*Gaura coccinea*	On Sunk Oyuspapi
Scarlet globemallow	*Sphaeralcea coccinea*	Heyoka Tapejuta
Scribner (panicum)	*Dichanthelium oligosanthes*	
Breadroot scurfpea	*Psoralea esculenta*	Tinpsila
Lemon scurfpea (slimleaf)	*Psoralea lanceolata*	
Silverflower scurfpea	*Psoralea agrophylla*	Mato tatinpsila
Slimflower scurfpea	*Psoralea tenuiflora*	Wahpe peji
Shell-leaf penstemon	*Penstemon grandiflorus*	
Slender leaf collomia	*Collomia linearis*	
Smooth blue aster	*Aster laevis*	
Stiff sunflower	*Helianthus rigidus*	Wahcazi Tanka
Tall cinquefoil	*Potentilla arguta*	
Violet	*Violaceae spp.*	
Western ragweed	*Ambrosia psilostachya*	Canhlogan Wastemna
Western wallflower	*Erysimum asperum*	Canhlogan Pa

Table 5.4 Continued

Common Name	Scientific Name	Lakota Name
Forbs continued:		
White milkwort	*Polygala alba*	
Wild lettuce	*Lactuca serroila*	Wahpe inkpa jiji
Wild licorice (American)	*Glycyrrhiza lepidota*	Wanawizi Cikala
Woolly cinquefoil	*Potentilla*	
Woolly plantain	*Plantago patagonica*	
Wooly verbena	*Verbena stricta*	To Pestola
Yellow evening primrose	*Calylophus serrulatus*	Wahcazi Cikala
Yucca	*Yucca glauca*	Hupestola
Woody:		
Leadplant	*Amorpha canescens*	Zitka Tacan
Skunkbrush	*Rhus aromatica*	Canunkcemna
Western Snowberry	*Symphoricarpos occidentalis*	Oh sunk nasapi hu
Wild rose	*Rosaceae spp.*	Onjinjintka Hu
Ponderosa Pine	*Pinus ponderosa*	Wazi Can
Others:		
Lichen		Can Wiziye
Puffball		Hoksi Cekpa

(Roger, 1920 and Johnson and Larson 1999)

Chapter 6. Results and Discussion for Case Study III: Tribal University Bison

Introduction

Case Study III, Tribal University Bison, was managed by a Tribal University and the research site was located within one of several range units rotated with approximately 300 bison. The project land base was divided into rotational units and rotational grazing was done throughout most of the year, and stocked accordingly. Each subdivided pasture had good water sources provided through a pipeline into stock tanks. One pasture had a lake within it and one pasture had a creek running through it. Stocking rate is set by BIA regulations for the area which is typically 20 acres per AUM. Most of the pastures were fenced by five strands of high tensile electric wire.

Background

A face-to-face, in depth interview was conducted with 'Tim', the bison manager associated with Tribal University Bison. An enrolled tribal member, Tim described his roll in bison management beginning at a very young age when he was given the name "peji aki'cita" which means 'grass warrior' or 'one that takes care of the land'. When he was a teenager, Tim had a dream that compelled him to bring the buffalo back. He recalled his parents taking him to Wind Cave National Park. This dream and visit had a deep impact on Tim that prompted him to bring buffalo back to the Reservation.

> When I was about 21, I had a dream, not a vision, it wasn't a 'humbleca' (vision quest), but a dream to have buffalo be back here.

Tim believed then that something needed to be done to bring back buffalo to the Reservation. He explained:

> So I began a quest… I brought back 40 head of buffalo back to my reservation as part of the Tribal Game, Fish and Parks program. When I had retired from there about 20 years later we had built up a herd of about 350 animals. So my dream was coming true and we placed these animals on truly native range.

Tim gained his experience to run the tribal university's herd because he had grown up around cattle. He had managed his own cattle and horse operations, and had started the tribally-owned bison herd. When the university began their quest to begin a bison ranch, Tim was asked to lead this process.

> Later, after leaving the tribal program, I was approached by the University to start a bison ranch, this was to satisfy the needs of the scientific studies, cultural resources and just for the general health of the prairie.

Tim discussed how the University received their first 14 bison from Wind Cave National Park, explaining the significance of this place of origin.

> We felt this was symbolic for two reasons, Wind Cave is where we came from as a cultural beginning or spiritual beginning and it is where the buffalo came from. We also went with the number of 14 because that is the number of months that the Lakota use and that is the number of tipi poles in a tipi. Various segments of our lives are based on those numbers so we felt 14 was a symbolic gesture…

There were also practical considerations that were important in the herd's beginning.

> We also went out for a search for producers who wanted to donate bison to the university. That process being two fold, buffalo where cheap and people wanted to cut back on their herds and plus they got a tax deduction from the University.

With these origins in mind, responses to interview questions for Tribal University Bison are presented and discussed according to the research objectives described below.

Research Objective One:

To identify management practices associated with sustainability of bison introduction by American Indians.

Management practices associated with sustainability were explored through a series of questions regarding overall management, land and ecological issues, and economic issues.

Overall herd management

A live-and-let-live basis was the overall management theme for the University. Tim described his approach as:

> …the closest to natural setting as we can get. If an animal gets sick or hurt, it seeks out its own medicinal plants to help it or it dies. That is the way nature is and we maintain that system yet today.

This hands-off approach was reiterated through much of the interview.

> We don't do any manipulation, no vaccination or dehorning, or anything like that.

> No medicated supplements. Bison are known to search out native plants on range lands. They utilized sage, lead plant and soap for medicinal purposes.

Tim explained the approach to range management and feeding of the bison, and described how limited pasture and drought conditions impacted management. Due to

limited acres per animal and the on-going drought, Tribal University bison are fed bales of prairie hay beginning in the fall months and continuing through May to supplement their limited forage.

> We feed about 2000 bales of prairie hay and usually start about the end of November until the end of March. Due to the terrible drought we have been feeding until the first of September and carrying this out until the first of May.

Tim also discussed rotational grazing management approaches.

> Starting about January 1, we usually rotate the herds around. We got eight different pastures. We move the animals from one pasture to the next and as we pass them through the corrals, we don't do any manipulation…

The theme of the hands-off approach continued throughout the discussion of Tribal University Bison's management practices. Tim explained that during the spring months, the animals were left alone to have their calves and bulls were not separated from the cows and calves.

> We don't keep track if the cow has a calf or not. We have an 80% calf crop in an average year…last year we had about 70% calf crop and this year we had about 60% calf crop. Again, drought conditions were a factor.
>
> Last year it was a dry year and there was no grass. I was always told by a variety of people and it has held true, that if buffalo aren't in good shape they won't calf.

Despite their conditions, Tim believed the buffalo "are terribly great for taking care of themselves."

Tim felt that most of the animals were in sync with the breeding season.

> It never seems to be too out of order. They seem to know when to breed or calf in an orderly fashion. We don't have more than four or five calves born out of a timeline of when they are suppose to. That isn't bad with 500 cows, that isn't too bad….

Tim also explained that calves were not weaned away from their mothers.

> (There is) No need for weaning. When a calf is born, it has a full set of teeth…He is ready to eat when he hits the ground. Of course, he drinks his mother's milk, and eats grass every day and by fall it weighs around 450 pounds. There isn't anything wrong with that.

Tim explained that Tribal University Bison did not cull bulls or cows from the herd.

> We don't do anything with the older bulls. They are not butchered. (They are) no longer breeding stock and they are just left to be sentinels of the hills for people to look at.
>
> (There are) No, culling practices (with cows) unless there is something drastic, some deformity or injury that will prevent her from being able to produce a calf.

During the summer months, Tribal University bison were left to their own devices, only to be moved periodically through the subdivided pasture system. This system was also used for sorting out animals needed for meat, bull rotation and to move animals through the pastures. Tim explained:

> …we do run the animals through the system and the sorting tub facilities and we usually select 50 head of butcher bulls anywhere from 2 to 4 years old…

Tribal University Bison round-up was done about four times per year to pull off animals that would be used for meat and to let the bulls mingle around with other herds of cows. This was described as bull rotation.

> We will open the pasture gate and let some of the bulls mingle in with the other animals. That is our idea of bull rotation.

Tim described in detail a research project that the University undertook to determine how much calves weigh when they are born. It provided valuable information, but he believed that they would not do this again because of stress on the cows and calves as well as the destruction of valuable equipment during the process.

> We did do one study about 5-6 years ago and on 30 head of new born calves, a very tricky operation and the average weight of birth for a heifer calf was about 47 pounds and bull calves weighed about 55 pounds at birth. We totally sacrificed a Chevy 4-wheel drive pickup… we had the sides of the pickup built up so she (mother cow) couldn't jump in the back of the pickup… It never seemed to matter how old the cow was they were always upset when their calves were taken to be weighed.

Animal identification was not an issue for Tribal University Bison. Tim explained that some animals had ear tags, a system for aging, but these were animals that had been brought in from outside the herd. Also through a United States Department of Agriculture (USDA) contract, some animals had computer micro chips implanted in them.

> …they (USDA) wanted to do measurements, weight, hair color and conformity. And we didn't want to do that. We feel that bison are like Lakota and they come in all shapes and sizes. If Tunkashila (Great Spirit) wanted us to be all one, there would be no variation in the world.

Some animals that were donated to Tribal University Bison were in poor condition due to drought that was more severe in other parts of the country. These animals were fed separately until they could gain some weight and be introduced to the other animals.

Most management decisions were made by Tim based on the behavior of the bison herd. Top priorities were first to maintain the herd health and second, to provide

safety for the herd. Tim was adamant about not looking for some things in the herd, which other producers might, due to cultural implications.

> (We are) not looking for the top production. (We are) not looking for genetics. We aren't going to haul a pen load of heifers to the Denver Stock Show and try to win.
>
> The only thing I watch for is getting animals from a disease-free herd and good looking, healthy animals.

The management of the bison included butchering between three and six animals per month under USDA regulations. These animals were all tested for brucellosis and tuberculosis before slaughter. None of the tested animals had reported a positive test. Every animal that came to the university was tested and all were disease free. Tim admits these testing practices were implemented mostly due to the local cattle ranchers, and their feelings about the herd, and concern about possible diseased buffalo infecting their cattle herds.

> So we tested and vaccinated at times to satisfy the ranchers, more than we think we need to protect the herd.

The herd size for Tribal University Bison grew significantly during the years immediately preceding this interview. However, Tim believed that Tribal University is now at a place where they can manage the herd successfully.

Environmental sustainability

Acquiring land to sustain the growing herd was the main issue that was related to environmental sustainability for Tribal University Bison. As quickly as the herd grew, more land was needed to sustain them; and therefore, the other natural resources such as

water, plant and forage viability became concerns for herd management. The first pasture for the bison herd was obtained through a decision made by the tribal council to assist the University with their endeavors as a land grant college. There were also areas of concern in different pastures as they were obtained through the tribal leasing program. One of the main concerns was supplying water to the herd. Tim discussed the herd's multiple water sources: "We have five tanks… 9 electric pumps… A creek runs through it and a lake…"

Tim was upfront on how many acres each pasture contained and the cost associated with that. Drought was a huge concern for maintaining the growing herd as well as trying to take care of the desired native plant life the University believed was also very important for the well being of the herd and the land itself. Tim explained:

> After three years of drought they (pastures) are in pretty poor condition. There is some species of grass that just hasn't rebounded back after one year. We have tried to maintain good grass with water every ½ mile; good proper rotational grazing, good cross fencing, but the drought really screwed us up for a while.
>
> Just the drought and the buffalo grazed it real hard. BIA was giving us a hard time and threatened to round them up until they seen how healthy they (the bison) looked.

Trying to do rotational grazing and trying to maintain an adequate stocking rate were some of the methods that Tim used to address issues of environmental sustainability. A select number of animals were placed in a rotational grazing pattern. This was determined according to the amount of acres per pasture and the health of the available forage.

> How they fit into the rotational grazing pattern. 250 animals on this piece here on three pastures…you could have the entire herd in the whole piece,

> but we try to split it. That way the grass has a little more time to rebound. Buffalo are pretty good about not staying in one place too long.

The University also felt strongly about maintaining native plants for the bison.

> All of the acres we have are all native range…except for the old irrigation piece that is the only property we don't have native range. As far as you can see, except for the alfalfa field, it is all original range like it was 200 years ago… We try to preserve the property and we want to continue this as a buffalo project…

Economic sustainability

One of the primary objectives of Tribal University Bison was to get the herd to a size where they could have an adequate amount of animals to harvest for the University's purposes. Tribal University utilizes meat from the bison herd for cultural purposes, and for university student meals. The university also produces and processes bison from the herd into jerky and meat sticks for profit to help sustain the herd economically.

Tim explained:

> The University itself uses about 40 pounds of meat a day, four days a week…Every student is fed two buffalo burgers or a bowl of soup….at $2.00 a plate at dinner. Students are virtually going to school on nothing and we feel it is our job to help make that a little easier…

Economics and profit however, were described by Tim as a secondary concern for the Tribal University Bison. Tim knew with the amount of meat that was given away that the project would not be self-sustaining, economically.

> 30,000 lbs of boneless meat product goes to the public each year. That is for any organization, civic organizations, schools, family things, memorials, honoring or funerals.

> You can't donate 30,000 lbs of meat a year, and be self-sufficient, but we try to take care of the people. We are here to feed the people and that is what we are here for and that is our major concern, not the economics.

However, there were efforts to make the most of what was sold for profit such as through the sales of jerky and hot sticks. Tim explained, "About 1/3 of our meat goes to the processing of meat sticks and jerky. We sell in the neighborhood about 10,000 buffalo sticks per year… (and) 1600 packages of jerky each year…"

Donations to Tribal University for the bison project also helped with the daily expenses of running the operation. Tim understood that building a herd and the large Tribal University Bison enterprise takes time.

Haying operations for Tribal University Bison, which were done in conjunction with a local rancher's haying operation, allowed the tribal university to share equipment and labor. This was a successful cost sharing strategy. Tim explained the partnership.

> We furnish a couple of tractors to the local haying operation, the rancher does all of the work but he doesn't have enough people in the operation, so we run a wind rower for him and a baler for him. We do this on shares, on our land.

Other things that were done for management purposes included utilizing the younger bulls and sorting those off several times. There was some thought given to meat quality when animals were sorted into the subdivided pastures.

> …we try to select on meat quality based on good, healthy looking animals, but it isn't our first priority. These animals (2-4 year old bulls) are kept in an 80 acre confinement operation and throughout the first six months of the year and butchered during that time.

However, the tribal university was reluctant to probe issues of quality or genetics in depth, regardless of their potential economic benefit. Jim explained:

> Why don't we do a study on meat management, meat gain, and genetics? It all relates back to something we (Lakota) try not to forget…the federal government for years and years labeled, selected Lakota by name, enrollment, blood quantum, and established guidelines like that. In the last 40 years we have tried to beat that process. We feel that if you are Lakota, you're Lakota. It doesn't matter if you are 1/8 or 7/8, and if you're a buffalo, you are a buffalo.

Marketing of live animals was not done. Marketing was only done through meat sales due to cultural implications.

> We do not market any breeding bulls or hunts. It is all against the thought of the Lakota. Like I said, we are here to help each other not sell each other. We consider these buffalo as our brothers and sisters. It would be like selling a relative.

Marketing of by-products was not done by the tribal university. All of the skulls and hides were used by the local Sundances, and none of the skulls were used for anything but cultural purposes. Some of the hides were used for a unique purpose. But all of the by-products were used for cultural purposes and none were sold. Tim explained:

> The skull and hides are used by the local Sundance people. There are enough sweat lodges to take all the skulls. We do tan a lot of hides and a hide is presented to a donor based on the donation. We do not market any of our hides. Some of the hides are used for drum heads or raw hide. All the internal organs are kept and utilized by the local people.

Financial health of the bison herd was a concern for the university. But the attitude of Tribal University and Tim was optimistic.

> We aren't broke and we are on an even plane...The health of the operation is based on what is going on out there (the market).

Daily expenses could add up, and Tim expressed concerns for unplanned expenses such as a tractor breaking down. But Tim felt for the most part the project operated efficiently with minimal resources.

Employment was also a concern and 'trying to be creative' in paying for help was also an issue at times.

> We have students come along and help us fix fence. My salary comes from the foundation of the University. I am more than just the bison manager, I am the land manager for the University…. I provide leadership to what type of buildings we are going to build and inspect the buildings… So my salary is paid for. My ranch foreman gets paid through being a student here. So part of it (his salary) comes from student services and part of it comes from the foundation here. The other young gentleman is paid by what ever money we can get…We do use volunteer help…to put up several miles of fence.

The main financial concern for Tim and Tribal University was the issue of paying the tribe for the lease of the land for the herd. Donations and selling of bison products were the primary means of paying for the large lease amount that was needed to secure the land from the tribe for the bison herd.

Most management decisions for Tribal University Bison were made by Tim, however at times there had been some opposition to his management based on financial issues. One such issue related to the students' needs versus the buffalos' needs. This issue related to the need to lease more pasture for the bison due to the drought and the need to offer more classes for the students.

> So the president of the university and I decided that we would sacrifice the classes for the buffalo. So the University, at the time, could not offer the classes. The line was drawn in the sand…Not everyone understood that sometimes you have to sacrifice for the buffalo.

Research Objective Two:

To explore the role of American Indian culture in the management of bison for sustainability.

Culture

Cultural considerations impacted all aspects of Tribal University Bison management. Virtually all of Tim's responses related to management decisions, environmental and economical sustainability decisions were based on cultural factors. Tim was not direct in sharing about culture but he indirectly communicated his perspectives throughout the interview. He said:

> …Bison are the same as us and that is how we feel about them. They are our brothers and our sisters; we try to treat them with the same respect as we treat each other.

Education was another important theme for Tribal University Bison management. Tim explained:

> We try to educate all the people that come here to the University about the cooperation between bison and the people and the social systems that they have taught us. We have a strong educational concept, we provide workshops in plant and animal management, hide tanning in a traditional setting with brain tanning and no mechanical tools…
>
> We try to keep the cultural part alive and well…

When asked about how the cultural goals impacted the approach to bison management, Tim did not hesitate to give the following response.

> Sometimes we can't meet the needs of our cultural components and we (the people) have to do without, because we won't sacrifice the bison for us to meet our needs. …we make due with what we got.

Tim expressed the importance of ceremony as part of the management process.

> All the animals that are taken to the slaughter are slaughtered on site (in the pasture). Songs are sung, and prayers are said in a timely manner. We sing like the 'Four Directions' song and the 'Buffalo Are Returning' song.
>
> If anyone wants to offer a prayer for the journey of the buffalo they can do that and we make that public when we are going to butcher. In the University data, internet system, we put it out on the email, the date and time and you are welcome to participate. The whole thing is an example of our culture, the bison herd.

The last questions were geared to the community response, barriers, needs and successes of this operation. Tim felt the community response to the University herd was mostly positive, but not with out concerns from local ranchers.

> This bison ranch… was a cattle ranch before we put buffalo on it and these cattle ranchers controlled it… there was some animosity to that. That forced them to go somewhere else with their cattle operation.

Themes that emerged on the barriers were mostly related to money and rain, but Tim felt that they were making it. He explained:

> They (University) will continue to educate on the culture and land management; feed the people; and take care of the buffalo and land so that they (buffalo) will take care of them.

Tim described the program's success as "Just getting the buffalo back and getting them here in numbers that people notice and continue on..."

Research Objective Three:

To investigate rangeland criteria that could be used to measure sustainability of bison reintroduction by American Indians

The research plots at Site 3 were on an Anselmo-Tassel-Dunday soil association on 5-9%, east-facing slopes. The predominant Anselmo soil series is deep and well drained. The soils are formed in wind-deposited sandy material that is friable when moist. The plant community was primarily mixed- grass species dominated by *Pascopyrum smithii* (western wheatgrass)*, Bouteloua curtipendula* (side-oats grama)*, Schizachyrium scoparium* (little bluestem) and intermittent forbs.

At Research Site 3, toe-slope positions were in a sandy/gravel soil area resulting in lower organic matter and soil water contents than found in the other slope positions (Table 6.1). Gelderman and Gerwing (2005) reported that organic matter concentrations for soils sampled in "West River" South Dakota in 2004 averaged 35 g kg^{-1}, which falls in the medium range between 31 to 40 g kg^{-1}. Our concentrations at Research Site 3 ranged from 17 (very low) to 37 g kg^{-1} (medium).

Aggregate stability is a physical soil quality indicator (USDA, 2001). However it is often the result of biological activity in the soil and is used to indicate a soils' ability to resist erosion. The aggregate stability at Research Site 3 was lowest in the sandy toe-slope (954 g kg^{-1}) but still indicated very good resistance to erosion. The high values for aggregate stability may be attributed to the plant species diversity, resulting in "root diversity" (Gijsman and Thomas, 1995; Chan and Heenan, 1996), and perennial ground cover (Eynard et al., 2000; Haynes and Swift, 1990).

Soil water content at Research Site 3 was less than 10 g kg^{-1} , typical of sandy loam soils (USDA, 1998). Soil water content decreased significantly from shoulder slope

(82 g kg^{-1}) to toe slope (32 g kg^{-1}) the reverse of trends found at the other three research sites.

Table 6.1. Soil quality variables as influenced by slope position and grazing at site 3.

		Soil Quality Variables[1]		
Slope Position	Grazed	OM[2]	AS[3]	Water[4]
		g kg^{-1}	g kg^{-1}	g kg^{-1}
Shoulder	yes	37	973	82
Mid-slope	yes	34	971	54
Mid-slope	no	30	978	48
Toe	yes	17	954	32
Pr>F		0.0001	0.0008	0.0019
$LSD_{.05}$		6.4	10.1	21.9

[1]Soil quality samples were collected at the 0-20 cm depth in May of 2003 and 2004.
[2]OM = Soil organic matter
[3]AS = Aggregate stability
[4]Water = Gravimetric soil water

Nitrate-N and phosphorus concentrations were not significantly different due to slope or grazing treatments at Research Site 3 (Table 6.2). Nitrate-N concentrations were higher than the 3.6 mg kg^{-1} average for SD grasslands (Gelderman and Gerwing, 2005). Phosphorus was in the very low to low range. However, 37% of soil samples from the West River region in SD fall within these categories (Gelderman and Gerwing, 2005).

Potassium in the toe slope was significantly different than other slope positions and grazing treatments (Table 6.2). Potassium concentrations were significantly higher in the shoulder position (473.7 mg kg^{-1}) than the mid-slope ungrazed position (396.0 mg kg^{-1}) and toe position. This decrease in potassium occurred with increasing sand and gravel content moving down slope. However, all potassium concentrations at Research

Site 3 were in the very high category for plant production. West River potassium concentrations in 2003-2004 averaged 514 mg kg^{-1} (Gelderman and Gerwing, 2005).

Soil pH at Research Site 3 was higher in the shoulder slope than other slope positions or grazing treatments (Table 6.2). The pH range at this site was adequate for normal range plant growth. Average West River pH was 7.0 in 2003-2004 (Gelderman and Gerwing, 2005).

Electrical conductivity was significantly higher in the shoulder position (0.4 mmho cm^{-1}) compared to other positions (Table 6.2). Average electrical conductivities found in this region in 2003-2004 were 0.76 mmho cm^{-1}. Salt concentrations below 3.0 mmho cm^{-1} are not considered limiting to plant growth.

Table 6.2. Soil chemistry variables as influenced by slope position and grazing at Site 3.

		Soil Chemistry Variables[1]				
Slope Position	Grazed	NO_3-N	Olsen P	K	pH	Salts
		mg kg^{-1}	mg kg^{-1}	mg kg^{-1}		Mmho cm^{-1}
Shoulder	yes	6.6	2.3	473.7	7.28	0.4
Mid-slope	yes	5.4	4.5	444.7	6.65	0.2
Mid-slope	no	6.3	2.8	396.0	6.62	0.2
Toe	yes	5.5	4	300.2	6.35	0.2
Pr>F		0.6797	0.09	0.0019	0.0001	0.0001
LSD $P>_{.05}$		NS	NS	80.2	0.3	0.1

[1]Soil qualities samples were collected at the 0-20 cm depth in May of 2003 and 2004.

There were differences in dry matter production due to slope position and grazing treatments at Research Site 3. Mid-slope ungrazed production was greater than mid-slope grazed and shoulder positions. Toe slope production was significantly more than the shoulder slope position, which would not have been expected with the sandy toe-slope soils with limited water holding capacity. Higher dry weights at the toe-slope

position may have been due to the increased number of woody plants in this area. In the study by Sims, et al (1978), in South Dakota, the dry matter production was 2330 kg ha $^{-1}$ for ungrazed and 1180 kg ha $^{-1}$ for grazed (50% difference).

No differences were found in crude protein, ADF and NDF due to slope positions or grazing treatments at Research Site 3 (Table 6.3). Jurgens (1996) reported that the typical concentration of crude protein in sun cured hay was 60 g kg^{-1}, slightly less than our findings, but similar to those reported by Severson (1982) in his Black Hills study. The ADF and NDF concentrations at this site were similar to Research Sites 1 and 2.

Table 6.3. Plant variables as influenced by slope position and grazing during at Site 3.

		Plant Variables[1]			
Slope Position	Grazed	CP[2]	ADF[3]	NDF[4]	DMP[5]
		g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}
Shoulder	yes	81	433	622	1126
Mid-slope	yes	85	417	592	1779
Mid-slope	No	83	442	631	3057
Toe	yes	72	439	604	2395
Pr>F		0.1595	0.3529	0.6376	0.0003
LSD P>$_{.05}$		NS	NS	NS	715

[1]Plant variables were collected at peak standing crop in July of 2003 and 2004
[2] CP = Crude Protein
[3] ACF = Acid Detergent Fiber
[4]NDF = Neutral Detergent Fiber
[5] DMP = Dry Matter Production

The plant inventory at Research Site 3 included 17 grass and grass-like, 48 forb and 3 woody species (Table 6.4). Plant diversity in rangeland systems provides resilience in the ecosystem and promotes the cycling of energy and nutrients (Sayre, 2001). Sims et al. (1978) found 54 plant species in a similar mixed prairie site. They also found 3 to 4 times more forb species than grass species. Diversity in root types helps build soil

structure (Chan and Heenan, 1996). Twenty five percent of the species at Research Site 3 were grasses, similar to the 23% reported by Collins et al., (1998) on the Konza Prairie.

Table 6.4. Plants identified at Research Site 3.

Common Name	Scientific Name	Lakota Name
Grass and grass-like		
Big bluestem	*Andropogon gerardii*	Peji Sasa Okihe Tankinkinyan
Blue grama	*Bouteloua gracilis*	Peji Okijata
Crested wheatgrass	*Agropyron cristatum*	
Field horsetail	*Equisetum arvense*	
Green needlegrass	*Stipa viridula*	
Intermediate wheatgrass	*Agropyron intermedium*	
Japanese brome	*Bromus japonicus*	
Kentucky bluegrass	*Poa pratensis*	Peji Blaskaska
Needleandthread	*Stipa comata*	
Prairie junegrass	*Koeleria macrantha*	
Prairie sandreed	*Calamovilfa longifolia*	Santuhu hcaka
Porcupine grass	*Stipa spartea*	Micapeca
Sedge (all)	*Carex spp.*	Psin tanka
Sideoats grama	*Bouteloua curtipendula*	Wapaha Kimnimnila Peji
Smooth brome	*Bromus inermis*	Peji hanskaska psi iyececa
Switchgrass	*Panicum virgatum*	
Western wheatgrass	*Pascopyrum smithii*	Pejihcaka
Forb:		
White penstemon	*Penstemon albidus*	
Bush morning glory	*Ipomoea leptophylla*	
Bract spiderwort	*Tradescantia bracteata*	Canhlogan panpanla

Table 6.4 Continued

Common Name	Scientific Name	Lakota Name
Forb continued:		
Cutleaf ironplant	*Haplopappus spinulosus*	Wahcaziwastemna
Daisy fleabane	*Erigeron strigosus*	
Dotted gayfeather	*Liatris punctata*	Tate Cannuga
False gromwell	*Onosmodium molle*	
Field bindweed	*Convolvulus arvensis*	
Flodman's thistle	*Cirsium flodmanii*	
Goatsbeard (salsify)	*Tragopogon dubius*	
Hairy goldaster	*Chrysopsis villosa*	
Giant goldenrod	*Solidago gigantea*	
Canada goldenrod	*Solidago canadensis*	Wahca ziblu
Prairie goldenrod	*Solidago missouriensis*	
Stiff goldenrod	*Solidago rigida*	Canhlogan maka ayublaya
Hairy vetch	*Vicia villosa*	
Lambsquarter	*Chenopodiaceae album*	
Whorled milkweed	*Asclepias verticillata*	Wahpe tinpsila
Common milkweed	*Asclepias syriaca*	
Common pepperweed	*Lepidium densiflorum*	
Poison ivy	*Toxicodendron rydbergii*	Wikoska Tapejuta
Prairie coneflower	*Ratibida columnifera*	Asanpi Iyatke
Pricklypear cacti	*Opuntia spp.*	Unhcela Blaska
Purple coneflower	*Echinacea angustifolia*	Icahpe hu
Purple prairie clover	*Dalea purpurea*	
Rush skeleton plant	*Lygodesmia juncea.*	Canhlogan Hu Can Swula Un He Tuktektel Yuke
Cudweed sagewort	*Artemisia ludoviciana*	Peji hota ape blaskaska
Green sagewort	*Artemisia dracunculus*	Canhlogan Wastemna
Scarlet gaura	*Gaura coccinea*	On Sunk Oyuspapi
Lemon scurfpea	*Psoralea lanceolata*	
Silverflower scurfpea	*Psoralea agrophylla*	Mato tatinpsila
Slimflower scurfpea	*Psoralea tenuiflora*	Wahpe peji
Shell-leaf penstemon	*Penstemon grandiflorus*	
Slender Aster	*Aster subulatus*	
Snow-on-the-Mountain	*Euphorbia marginata*	Asanpi pejuta
Stiff sunflower	*Helianthus pauciflorus*	Wahcazi Tanka
Tall cinquefoil	*Potentilla arguta*	
Virginia groundcherry	*Physalis virginiana*	
Wavyleaf thistle	*Cirsium undulatum*	
Western ragweed	*Ambrosia psilostachya*	Canhlogan Wastemna
Western wallflower	*Erysimum asperum*	Canhlogan Pa

Table 6.4 Continued

Common Name	Scientific Name	Lakota Name
Forb Continued:		
White sweet clover	*Melilotus alba*	
Wild licorice (American)	*Glycyrrhiza lepidota*	Wanawizi Cikala
Woolly cinquefoil	*Potentilla*	
Woolly plantain	*Plantago patagonica*	
Wooly verbena	*Verbena stricta*	To Pestola
Yellow evening primrose	*Calylophus serrulatus*	Wahcazi Cikala
Yellow sweet clover	*Melilotus officinalis*	
Woody:		
Common Name	Scientific Name	Lakota Name
Leadplant	*Amorpha canescens*	Zitka Tacan
Western Snowberry	*Symphoricarpos occidentalis*	Oh sunk nasapi
Wild rose	*Rosa spp.*	Onjinjintka Hu

(Rogers, 1920) and Johnson and Larson, 1999)

Chapter 7. Results and Discussion for Case Study IV – Tribal Bison

Introduction

Case study IV was managed by Tribal Fish and Wildlife and was located within a 530 ha range unit that had been stocked with approximately 80 bison since 1995. There was adequate water in all of the pastures supplied mostly by wells. There was year-long grazing in the pastures. Stocking rate was set by BIA regulations for the area which is typically 20 acres per AUM. The pastures are fenced with either a woven game fence or a high tensile electric fence. The tribe has more than 250 animals on several large holdings of land on the reservation. The herd within the pasture that had the research site was comprised primarily of animals from the tribe.

The management was primarily a hands-off approach with minimal handling of the animals. There were no vaccinations and no disease testing at this time. There was little to no supplement feeding done in any of the pastures that the tribe managed.

Background

A face-to-face, in-depth interview was conducted with 'John', manager of Tribal Bison. John is an enrolled tribal member and his experience before becoming involved with the bison management program for the tribe was with cattle. He grew up on a ranch and also had some educational experience related to livestock production. He had some expertise in running a business and was knowledgeable on issues related to land and resource management.

Tribal Bison was begun in the 1970s, and has grown over the years to its present size. The herd's first animals were obtained from Wind Cave National Park. The animals that

stocked the new pasture (the tribe has three different pastures) that was developed in the 1990s, came from surplus animals from the tribe and from an agreement with the National Park Service. As members of the Inter Tribal Bison Cooperative (ITBC), the tribe was eligible for surplus animals through this agreement. John explained:

> Most of these animals came from the agreement ITBC had with the national parks on getting surplus animals at the time. So each year we would put in for so many buffalo and hope we would get some.

Responses to interview questions for Tribal Bison are presented and discussed according to the research objectives described below.

Research Objective One:

To identify management practices associated with sustainability of bison introduction by American Indians.

Overall herd management

Tribally Managed Bison took a "hands-off" approach to management. John described this approach:

`

> We don't round them up unless absolutely necessary. We (used to) try to round them up and ear tag the new calves every year, but don't feel it is necessary anymore. At first we were handling them too much and realized that it wasn't necessary to do anything with them other than make sure they had enough grass. Hands-off mostly is our management style. We let them do what they want to.

John explained that herd health and feeding was also approached in a hands-off manner.

> We do provide lick tubs and some cake and hay when they need it, but otherwise we do little supplement feeding. Some animals have not been touched for years. Anthrax vaccinations were done since we had some scare with anthrax in recent years, but we normally do not do any other

> vaccinations unless we have to move them. Since we are close to the river, we do provide some tick bags for parasite control, but they usually avoid them (tick bags).

No specific management practices were implemented with the herd during breeding season, and only a little 'cake' was provided during calving season. No weaning was done by Tribal Bison. No cow-to-bull ratios were kept. Top priority for Tribal Bison was to maintain a healthy herd . This was done by providing adequate forage for the animals. John said: "Health is top priority…grass condition is very important to maintain herd health."

Culling of the herd was done periodically so that old and/or sick animals could be eliminated as needed. This was only done when necessary to remove animals to balance the stocking rate and the forage availability.

Herd numbers fluctuated due to balancing the ratio between animal numbers and forage availability. Land availability and complex tribal land ownership patterns on the reservation were issues when considering expanding the Tribal Bison herd. John explained:

> The herd size increase(d), then decreased and increased again, but now we have a comfortable number of animals for what we need and (the) pasture that we have. Some of our buffalo pastures are tribal land and some is deeded land. One unit was bought land and then turned back into tribal trust. We do have to pay lease on the land to the tribe for the buffalo pastures. We went to the Tribal Council and they gave us some land for the buffalo program. Land…is the main factor, it is difficult to get the land and expensive, so we try mainly to maintain our numbers. We would like to expand, but I don't see that happening anytime soon due to land issues. If given the opportunity we might expand…

Environmental sustainability

John said that pasture condition was the key to success for both a healthy herd and a healthy environment. Having good water sources was also a priority for John and Tribal Bison. Maintaining good pasture condition was John's priority; this was accomplished, according to John by trying to keep the balance between herd numbers and acres. He said they worked to have good dams and wells in each of the operation's pastures, and described the overall condition of the pasture as "good to excellent".

John discussed how drought had taken a toll on the overall condition of the pastures. Lack of moisture from snow and weather conditions were a concern for the environmental sustainability of Tribal Bison.

> Weather and drought have taken a toll in some years… moisture conditions have affected the pastures and winter snows. There just isn't enough moisture for the pastures.

Stocking rate was dictated by the BIA and the tribe did their best to maintain that number. However, John believed that the bison might be a bit better at utilizing the pasture then cattle. He explained:

> BIA tells us what to do (stocking rate). We are usually over-stocked but our pastures still look good. We just do year-long grazing with no cross fencing. It seems to work for us. They (bison) rotate themselves around the pasture to utilize grass better then cattle do. We do have some prairie dog problems, but they don't seem to bother us too much.

Concern for range condition emerged as a priority for John and Tribal Bison.

> BIA regulations and carrying capacity have been some of our important (land) issues. Range condition has always been important. We have tried to utilize our resources well. We have a contract with Natural Resources Conservation Service and they have helped us put in a dam.

Economic sustainability

From John's view, the economic goal for Tribal Bison was simple and to the point.

> Eventually we want to be self sufficient and be able to survive off our hunts and meat sales. We want to stay productive and keep things going.

Financing for the herd was done in-house through buffalo hunts and jerky meat sales. Tribal Bison also utilized their membership in ITBC. John explained:

> We do have money in-house, but we get a little from the tribe every once in while when we fall short. ITBC has helped us a lot to get equipment, fencing and buffalo in the past through their funding. We did have a USDA meat buy out once that was generated through ITBC, but we mostly sell hunts and do meat marketing with our jerky. It works for us. We go in to the herd and select out several animals to process. We do this when we need to, when we start running short on jerky or meat.

Tribal Bison by-products are sold occasionally, but most are given away. Hides were not commonly utilized, John explained:

> We don't do much with the hides…Skulls are given away to who ever wants one and for what ever purpose such as sweat lodges and artist. We give meat way for pow-wows, and funerals and wakes…

The financial health of Tribal Herd was good according to John, but he felt that other than in-house money, ITBC support was useful in times of need.

> Our financial health is good, we are about even, even with poor prices on buffalo now. ITBC grants help, and some of our buffalo sales have helped. So we maintain. ITBC money has also helped us buy loading chutes, and help cover cost… We have been a member since 1995 or so. We have applied for money to expand our herd at times. They have provided us with what we need for the herd if we can't get the money in-house.

Research Objective 2:

To explore the role of American Indian culture in the management of bison for sustainability.

Culture

John did not discuss the role of culture in management practices in depth. He explained that cultural matters that pertained to the bison were left to the tribe's spiritual leaders. Bison that were killed for pow-wows or for ceremonial purposes were given the proper prayers and offerings. When asked how cultural considerations impact the tribe's approach to bison management, John said, "Let them be and keep them buffalo; don't try to make them into cattle."

Bison education was important to the tribe. The local tribal college, grade and high schools were welcome to do educational programs relating to the bison herd. Research and on-going community educational programs were commonplace. John described the tribal community as being supportive of the herd.

> Overall it (the tribal community) is supportive of the buffalo project because they can see them on a daily basis and know that they are there. People can see from the road and feel a connection to them.

On the whole, John was positive about the future of Tribal Bison. "We hope," he said, "to keep doing what we are doing…"

Research Objective Three:

To investigate rangeland criteria that could be used to measure sustainability of bison reintroduction by American Indians.

The research plots were on a Sansarc-Opal soil association on 6-15%, east-facing slopes. This soil association is formed in clayey shale residuum. The predominant series are moderately deep, well drained and steep. These clay soils have gray shale within one meter of the surface. The plant species are a mixed grass community dominated by *Pascopyrum smithii* (western wheatgrass), *Bouteloua spp.*(grama grasses), and *Schizachyrium scoparium* (little bluestem) with intermittent forb communities.

Soil organic matter and water content, and aggregate stability were used as soil criteria to estimate sustainability of re-introducing bison. Soil organic matter was not significantly different between slope positions and grazing treatments (Table 7.1). Gelderman and Gerwing (2005) ranked organic matter concentrations between 41 -50 g kg^{-1} in the high range with only 9% of soils sampled in "West River" South Dakota in this category in 2003-2004. Organic matter concentrations above 50 g kg^{-1} were considered to be in the very high range with 12 % of West River samples in this category. At Research Site 4, the organic matter was in the high to very high category compared to the other samples for this area and was the highest of the four research sites. Soil organic matter improves aggregate stability, nutrient availability and water holding capacity.

Aggregate stability at Research Site 4 ranged from 987 to 990 g kg^{-1} but was not influenced by slope position or grazing treatment. These values are slightly higher than those reported by Eynard et al. (2004) and reflect the high organic matter content

(Gollany et al., 1991) and grazing conditions (Haynes and Swift, 1990). The aggregate stability values indicate that the soils would be able to effectively resist erosion.

Water content at Research Site 4 was typical of silty clay and clay soils (USDA, 1998). Water content was not significantly influenced by slope position or grazing treatments.

Table 7.1 Soil quality variables as influenced by slope position and grazing at Site 4.

		Soil Quality Variables[1]		
Slope Position	Grazed	OM[2]	AS[3]	Water[4]
		g kg^{-1}	g kg^{-1}	g kg^{-1}
Shoulder	yes	49	987	142
Mid-slope	yes	51	988	144
Mid-slope	no	49	988	141
Toe	yes	58	990	133
Pr>F		0.3501	0.2693	0.4727
$LSD_{.05}$		NS	NS	NS

[1]Soil quality samples were collected at the 0-20 cm depth in May of 2003 and 2004
[2]OM = Soil organic matter
[3]AS = Aggregate stability
[4]Water = Gravimetric soil water

Nitrate-N concentrations at Research Site 4 ranged from 7.5 to 4.9 mg kg^{-1} but were not significantly different among slope positions or grazing treatments (Table 7.2). All values were higher than the 3.6 mg kg^{-1} mean reported by Gelderman and Gerwing (2005) for South Dakota grasslands.

Phosphorus was significantly lower at the mid-slope grazed position (4.8 mg kg^{-1}) than the toe slope (7.3 mg kg^{-1}) and shoulder position (6.7 mg kg^{-1}). Phosphorus was in the low range, as were 26% of soil samples from the region (Gelderman and Gerwing, 2005).

Potassium was significantly higher in the toe slope position than the shoulder position. The mean potassium soil test level for "West River" was 514 mg kg^{-1}, however all potassium levels were considered to be in the very high category for plant growth.

Soil pH at Research Site 4 was not significantly different among slope positions and grazing treatments and was typical for the "West River" samples (7.02). A soil pH of 6.8-6.9 is adequate for growth of rangeland plants.

Electrical conductivity, a measure of soluble salts, was not significantly different among slope positions and grazing treatments. The 0.5 mmho cm^{-1} level would not be limiting to plant growth, and is lower than the West River mean of 0.76.

Table 7.2. Soil chemistry variables as influenced by slope position and grazing at Site 4.

		Soil Chemistry Variables[1]				
Slope Position	Grazed	NO_3-N	Olsen P	K	pH	Salts
		mg kg^{-1}	mg kg^{-1}	mg kg^{-1}		mmho cm^{-1}
Shoulder	yes	5.5	6.7	438.8	6.9	0.5
Mid-slope	yes	5.5	4.8	478.3	6.8	0.5
Mid-slope	no	4.9	6.3	453.0	6.9	0.5
Toe	yes	7.5	7.3	535.5	6.9	0.5
Pr>F		0.1346	0.0394	0.031	0.5271	0.6344
LSD $P>_{.05}$		NS	1.69	65.29	NS	NS

[1]Soil qualities samples were collected at the 0-20 cm depth in May of 2003 and 2004.

Dry matter production at Research Site 4 was higher in the mid-slope ungrazed position than in the mid-slope grazed and shoulder slope positions (Table 7.3). The difference between grazed and ungrazed plots was 45%, higher than the other research sites, but similar to differences (44%) reported by Larson and Whitman (1942). In the

study by Sims, et al. (1978), in South Dakota, the dry matter production was 2330 kg ha^{-1} for ungrazed and 1180 kg ha^{-1} for grazed (50% difference).

Indicators of forage quality included crude protein, acid detergent fiber, and neutral detergent fiber (Table 7.3). Crude protein was significantly higher in the mid-slope grazed position than the mid-slope ungrazed position. ADF was significantly higher in the mid-slope grazed position then in the mid-slope ungrazed position and the toe slope position. NDF was significantly higher in the toe slope position than the other slope positions and grazing treatment. ADF values were similar to those reported by Severson (1982) for grasses in the Black Hills region of South Dakota.

Table 7.3 Plant variables as influenced by slope position and grazing during at site 4.

		Plant Variables[1]			
Slope Position	Grazed	CP[2]	ADF[3]	NDF[4]	DMP[5]
		g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}
Shoulder	Yes	80	434	640	1155
Mid-slope	Yes	86	417	631	1202
Mid-slope	No	74	451	652	2188
Toe	Yes	78	408	561	1781
Pr>F		0.0279	0.003	0.0046	0.0201
LSD $P>_{.05}$		7.2	21.2	47.5	706.6

[1]Plant variables were collected at peak standing crop in July of 2003 and 2004.
[2] CP = Crude Protein
[3] ACF = Acid Detergent Fiber
[4]NDF = Neutral Detergent Fiber
[5] DMP = Dry Matter Production

Included in the plant species inventory at Research Site 4 were 14 grass and grass-like, 39 forb, and 3 woody species. Plant diversity in rangeland systems provides

resilience in the ecosystem and promotes the cycling of energy and nutrients (Sayre, 2001). Sims et al. (1978) found 54 plant species in a similar mixed-grass prairie site. They also found 3 to 4 times more forb species than grass species. Twenty five percent of the species were grass or grass-like, similar to the 28% grass species reported form the Konza Prairie (Collins et al., 1998). Collins et al. found 64 species in grazed and 46 in ungrazed areas of the Konza. The similarity between our sites and the Konza Prairie, in grass:forb ratios and total number of species found, suggests that these range sites are suitable for bison re-introduction.

Table 7.4. Plant species identified at Site 4.

Common Name	Scientific Name	Lakota Name
Grass and grass-like:		
Little bluestem	*Schizachyrium scoparium*	Peji Sasa Swula
Big bluestem	*Andropogon gerardii*	Peji Sasa Okihe Tankinkinyan
Blue grama	*Bouteloua gracilis*	Peji Okijata
Canada wild rye	*Elymus canadensis*	Pteya hota
Green needlegrass	*Stipa viridula*	
Japanese brome	*Bromus japonicus*	
Kentucky bluegrass	*Poa pratensis*	Peji Blaskaska
Prairie junegrass	*Koeleria macrantha*	
Porcupine grass	*Stipa spartea*	Micapeca
Red threeawn	*Aristida purpurea*	Peji Takan Kaza
Sedge (all)	*Carex spp.*	Psin tanka
Sideoats grama	*Bouteloua curtipendula*	Wapaha Kimnimnila Peji
Smooth brome	*Bromus inermis*	Peji hanskaska iyececa
Western wheatgrass	*Pascopyrum smithii*	Pejihcaka
Forb:		
American vetch	*Vicia americana*	Tasusu
Beardtongue, Narrowleaf	*Penstemon angustifolius*	Canhlogan Hlahla
White penstemon	*Penstemon albidus*	
Blue lettuce	*Lactuca oblongifolia*	
Curlycup gumweed	*Grindelia squarrosa*	

Table 7.4 Continued

Common Name	Scientific Name	Lakota Name
Forb continued:		
Daisy fleabane	*Erigeron strigosus*	
False indigo	*Amorpha fruticosa*	Zintkalatacan
Field bindweed	*Convolvulus arvensis*	
Goatsbeard (salsify)	*Tragopogon dubius*	
Golden Aster	*Chrysopsis villosa*	
Giant goldenrod	*Solidago gigantea*	
Soft Goldenrod	*Solidago mollis*	
Groundplum milkvetch	*Astragalus crassicarpus*	Ptetawota
Hairy Vetch	*Vicia villosa*	
Whorled milkweed	*Asclepias verticillata*	Wahpe tinpsila
Poison ivy	*Toxicodendron rydbergii*	Wikoska Tapejuta
Prairie coneflower	*Ratibida columnifera*	Asanpi Iyatke
Purple coneflower	*Echinacea angustifolia*	Icahpe hu
Purple prairie clover	*Dalea purpurea*	
Pussytoe	*Antennaria spp.*	Canhlogan hu wanjila
Cudweed sagewort	*Artemisia ludoviciana*	Peji hota ape blaskaska
Fringed sagewort	*Artemisia frigida*	Peji Hota Wastemna
Green sagewort	*Artemisia dracunculus*	Canhlogan Wastemna
Scarlet globemallow	*Sphaeralcea coccinea*	Heyoka Tapejuta
Lemon scurfpea	*Psoralea lanceolata*	
Silverflower scurfpea	*Psoralea agrophylla*	Mato tatinpsila
Slimflower scurfpea	*Psoralea tenuiflora*	Wahpe peji
Sensitive briar	*Scrankia nuttalli*	
Slender aster	*Aster subulatus*	
Stiff sunflower	*Helianthus panciflorus*	Wahcazi Tanka
Virginia groundcherry	*Physalis virginiana*	
Wavyleaf thistle	*Cirsium undulatum*	
Western ragweed	*Ambrosia psilostachya*	Canhlogan Wastemna
Western wallflower	*Erysimum asperum*	Canhlogan Pa
Western yarrow	*Achillea millefolium*	Hante canhlogan
Prickly lettuce	*Lactuca serroila L.*	Wahpe inkpa jiji
Wild licorice(American)	*Glycyrrhiza lepidota*	Wanawizi Cikala
Wooly cinquefoil	*Potentilla*	
Wooly verbena	*Verbena stricta*	To Pestola
Yellow sweet clover	*Melilotus officinalis*	
Woody:		
Leadplant	*Amorpha canescens*	Zitka Tacan
Western Snowberry	*Symphoricarpos occidentalis*	Oh sunk nasapi
Wild rose	*Rosaceae spp.*	Onjinjintka Hu

(Rogers, 1920) and Johnson and Larson, 1999)

Chapter 8. Conclusion

You have to change your way of thinking about them.

It's a challenge, but it's a good challenge.

In this section, conclusions and common themes across the four case studies will be presented and discussed. The first issue to be addressed is the diversity of operations under examination. Tribal Community Bison, Tiospaye Bison, Tribal University Bison and Tribal Bison were unique enterprises, differing in size, scope, and approach. While each of the herds involved Native people in efforts to reintroduce bison to tribal lands, the individual managers were different in their ages, levels of prior experience, and motivations for involvement with bison. Similarly, while all were located on reservations in western South Dakota, biological analysis reflected diversity on the landscape as well. Diversity was evident in interpretation of key themes. For example, for some, 'hands off' management included rotational grazing, and providing some supplemental feed; for others, it did not. On the economic front, some wanted to be self-sufficient, where others accepted the fact that due to the large number of donations, that was not a realistic goal. And, while all stressed the importance of culture, cultural practices were integrated into management and marketing approaches in a variety of ways. Despite these differences, common themes did emerge across the four cases. These are highlighted below.

Common Themes

1.) Hands-off/natural approach to bison and natural resource management.

> We operated on a live and let live basis and we maintain that.
>
> We feel that is the closest to the natural setting we can get.
>
> I really want them to do their own thing.
>
> You think you are going to control them but you are not.

All four managers felt that a hands-off, minimally intrusive approach with bison was the best type of management. John, of Tribal Bison, described how their management had shifted to this more hands-off approach in recent years. This included little to no handling, no vaccinations, little or no disease testing, no assistance during calving or breeding, and minimal supplemental feeding unless over stocked for the pasture size or during extreme weather conditions. None of the managers practiced dehorning or castration of the animals. None of them practiced weaning or had an active program for culling of older animals. One manager mentioned "putting an animal down" when it was injured. Only one manager was interested in genetic testing. None of the four managers were concerned about or kept records of their herd's precise calving rate.

Joe, manager of Tribal Community Bison, reflected on this approach:

> Hey, I don't want to run them like cattle. I don't want to inject them with vaccines. I don't want to wean calves. I want the mother and calf to stay together as long as possible. The females, they have to be killed sometime and we don't like to do that. But I guess respecting the animals. NO feed lots. I don't want to have to put them in a trailer and take them to a processing plant. Get them all stressed out and have to kill them.

2.) <u>Concern for health and interactions of land, animals and people</u>

> I am interested in the grass, the water, the nutrition...the trees and all the animals and how they interact and get an inspiration from the animals and figuring out what kind of relationship they have with the other animals…that…is really interesting.
> I want to be sure we are taking care of the land.

A strong stewardship ethic was evident in all four case studies. There was a genuine interest in the "health of the land", "health of the prairie", "health of the herd" and "health of the operation" on the part of all of the managers. Drought was an underlying issue throughout the interviews. All managers were concerned about the health of the land. All managers believed that the pastures for the bison were in good condition despite the ongoing drought. Three of the four mangers felt they had adequate water sources in the bison pastures. Only one manager wanted to improve his herd's water sources. Stocking rate for all four case studies was dictated by Bureau of Indian Affairs (BIA) regulations and all four managers tried to adhere to those regulations and felt that the regulations were adequate for the area they managed. Only Tribal University Bison was practicing rotational grazing. Jim's Tiospaye Bison implemented a seasonal pasture rotation between two pastures. Most of the land for the herds was tribally-leased through the BIA. All of the managers indicated they would increase the land base for the bison project if given the opportunity. Land and ecological concerns were mixed and included wildfires, fencing, nutrition for the bison, carrying capacity, BIA regulations, and range conditions.

All four managers spoke about herd health as being one of their top priorities. This concern was rooted in what the managers described as a "deep respect" for the animals.

> (Herd) health is top priority.

> The management…(needs to)…take the animal into consideration first. The health of the herd is number one. (We are) not looking for top production. (We are) not looking for genetics. We aren't going to haul a pen load of heifers to the Denver Stock Show and try to win. If they are healthy, that is all we care about.

The concern for the well being of the land and the herd(s), expressed by the managers in the interviews was validated through the biological data collected. For each of the pastures, research showed soil water, nutrient content, aggregate stability and plant richness to be well within acceptable limits for their biomes. Similarly the pastures provided adequate quality and quantities of forage to maintain healthy nutrient levels for herd populations.

The managers also discussed the role of the bison in their communities. All four managers mentioned giving meat away for cultural and spiritual activities. Meat from each of the herds was contributed to community events such as pow-wows, funerals, wakes, ceremonial purposes and other cultural activities. Tim at Tribal University Bison described an extensive system for dispersing some 30,000 pounds of bison meat on their reservation each year, including daily meals at the university. He said:

> Having the buffalo here for the community and having access to the buffalo meat…it's been good...the collaboration and the people getting involved. (We want to)…get more buffalo meat back into the diets of the people…make it more affordable for people.

John at Tribal Bison said:

> We try to get the community involved and they see them from the highway and they like being part of that.

The very existence of Joe's herd, Tribal Community Bison, reflected the commitment, involvement and integration of the community in bison reintroduction. Further reflecting this stewardship ethic, all of the managers described the importance of ongoing, community-based education and research related to their herds.

Recall Joe's (of Tribal Community Bison) words:

> Our goal is to share, especially with Native people…what I have experienced…and put it together for people to understand it (the culture and the story) to learn more and to share more. I think it is good, and one of the things I am really interested in. I think it is real important we share the buffalo and the culture.

3.) <u>De-emphasized importance of economics</u>

> Don't go in it for the money. The cultural and spiritual issues are more important.

Economic goals for each herd were different, but all four managers agreed that being economically self sustaining was a goal. In some cases, such as Tribal University Bison, the operation was unlikely to be self-sustaining due to the amount of meat that was given away. As Tim said:

> "With the amount of bison meat we give away, you can't expect us to be 100% efficient".

This approach reflects an orientation beyond purely economic considerations, more commonplace in mainstream enterprise analysis. When asked about their herds' management priorities, none of subjects cited profitability as a major concern. All of the managers were interested in marketing of bison meat or bison meat products. One manager was very interested in marketing bison by-products and one expressed interest in developing an ecotourism enterprise to help support the bison herd. All four managers

were selling bison meat, bison meat products such as meat sticks and jerky and three were selling bison hunts. None of the managers were interested in selling bison at live auctions, due to respect for the animals. Three of the managers described the depressed market for bison meat and the current difficulties in making their operations profitable. One case study manager was very interested in field slaughtering animals versus taking them to the packing plant live; this was due to respect for the animal and trying not to stress the bison before slaughter. None of the managers were marketing by-products and all four managers were giving most of the skulls away for spiritual and cultural purposes.

All four managers had outside work, grants, donations or contributors to assist with the economics of their bison project. None of the four were relying solely on bison sales to generate revenue for the operation. Three of the four managers agreed that they were "getting by" financially. The financial issues for each case study were mixed. Two mentioned paying the pasture lease was one of the biggest financial issues. Access to and affordability of land was a primary financial concern for all of the operators. Other financial issues included fencing, finding markets for the bison meat or meat products and having enough help for the day-to-day management of the project.

John at Tribal Bison explained his persistence in spite of these financial obstacles this way:

> Don't look at it (the herd) as an alternative means to economics, and you need to go into it for the love of the animals.

Tim, manager of Tribal University Bison, considered economics in the larger context, saying:

> (We)…keep it somewhat simple. We try to take care of the people. We are here to feed the people and that's what we are here for and that is our major concern, not the economics.

4.) Importance of cultural issues

> Whatever we did with the buffalo was culture.
>
> Them being here is part of the culture.
>
> Without the ceremonies, things wouldn't be as they are.

All four managers were familiar with their tribe's cultural traditions associated with buffalo. Three of the managers expressed a deep cultural and spiritual connection to the bison and to what they are doing for the Lakota people either through their families, communities, students or tribe. The fourth manager, while he did not describe his own spiritual connection to the bison, acknowledged its importance and spoke of the important role tribal spiritual people played with the herd. Cultural traditions mentioned included the buffalo dance which was being performed by Jim's family from Tiospaye Bison. All managers felt that ceremony was an important part of bison management. Two managers mentioned the Sundance; and all managers described the Bison Kill Ceremony, songs that were sung and prayers that were offered before the buffalo were killed. Tim at Tribal University Bison described the integration of culture and herd management:

> All these animals that are taken to the slaughter or slaughtered on site, songs are sung and prayers are said in a timely manner. We sing like the 'Four Direction Song' and the 'Buffalo are Returning Song.' If anyone wants to offer a prayer for the journey of the buffalo they can do that…

All managers mentioned that the cultural goals were related to why they became involved in bison reintroduction. Two managers described their entrée to the buffalo as a 'calling' of sorts:

> As a young man, I was given the name 'peji aki'cita' which means 'grass warrior' or 'one who takes care of the land.' I had a dream…to have the buffalo being back here.
>
> Something told me to do it…maybe a dream, maybe someone, but something happened. (There is)…sort of a spiritual connection…but in my heart I had to go with it.

Three of the managers mentioned the Lakota being related to the bison and the respect for the animals. Tim, manager of Tribal University Bison, described his relationship to the bison as a form of kinship. These comments further reflect the power and importance of cultural considerations across the tribal bison reintroduction efforts examined in this research.

> Talking about that bison are the same as us and that is how we feel about them. They are our brother and sisters; we try to treat them with the same respect as we treat each other.

John at Tribal Bison put it this way: "We are related to them."

Summary

> They were looking for a place to have the Sundance. They bring their ceremonies and here it is. It's kind of right to have a Sundance here (in the buffalo pasture). To me, it's right, because the buffalo are a big part of the Sundance. Most all of the ceremony has to do with buffalo and it just falls in place.

The Lakota philosophy of *Mitakuye Oyasin*, 'all my relatives', reflects the Native belief in the interconnectedness of all aspects of life. This philosophy provides a useful framework for summarizing the foregoing study of reintroduction of bison to tribal lands.

One manager felt that there was more wildlife in the pasture than before the bison were reintroduced. One manager believed there were more native grasses coming back since the reintroduction of bison. Others discussed the growing interest in bison meat as part of the diet, bison art, bison tourism and bison culture, including the importance of sharing stories and songs with the next generation.

This holistic understanding was present in the approach of all four bison managers. Tribal Community Bison manager, Joe, described the interrelated aspects of his operation:

> Well, it seems to me I have…seen more…wildlife…more turkeys, more grouse, more birds…I think because of the buffalo and the management we have kept enough grass and cover. So the animals like that…and we have more water. I believe it (having the buffalo) has increased the overall health of the land.

The interconnected view of the bison managers was further evidenced in the managers' responses to questions on virtually all of the topics that were a part of the interview guide. For example, discussions about economics frequently spilled over into culture; questions about management practices sometimes elicited responses relating to community outreach or the environment. Upon review of the biological data and interview transcripts it seems that bison reintroduction to tribal lands is a fundamentally different process from cattle ranching or conservation of endangered species. The unique relationship between Native people and buffalo imbue this process with unique issues and concerns. Indeed, the bison reintroduction movement among Native American peoples today cannot be dissected or taken apart and examined, part-by-part, in isolation. Rather, to understand this movement is to come to a deeper awareness and appreciation of the

intersections between economics and community, science and culture, management, spirituality and the environment. The quantitative and qualitative data presented herein, when examined from this holistic perspective, offer valuable insight into the challenges, successes and unique perspectives of a diverse group of herd managers and contemporary Native leaders of tribal bison reintroduction.

Literature Cited

Axelrod, D.I. Anderson R.C., and Collins S.L. 1985. Rise of the grassland biome, central North America. The Botanical Review 51: 163-201.

Barbour, M.G., J.H. Burk, and W.D. Pitts. 1987. Terrestrial plant ecology. The Benjamin/Cummings Publishing Co., Menlo Park, CA.

Bengston, D. N. 2004. Listening to neglected voices: American Indian perspectives on natural resource management. J. of Forestry 102(1):48-52.

Berg, B.L. 2003. Qualitative Research Methods for the Social Sciences. (5th ed.) Boston: Allyn & Bacon.

Berger J., and C. Cuningham. 1994. Bison: Mating and conservation in small populations. New York: Columbia University Press.

Borchert, J.R. 1950. The climate of the central North American grassland. Ann. Assoc Amer. Geogr. 40:1-39.

Brewer, R. 1964. Fabric and mineral analysis of soils. John Wiley & Sons, New York.

Briggs J.M., and A.K. Knapp. 1995. Interannual variability in primary production in tallgrass prairie: Climate, soil moisture, topographic position and fire as determinants of aboveground biomass. Am. J. Bot. 82: 1024-1030.

Burns, R. 1990. Introduction to research methods. Melbourne: Longmans.

Callenbach, E. 1996. Bring back the buffalo!. Island Press, Washington, DC.

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

Catlin, G. 1844. Letters and notes on the manners, customs, and condition of the North American Indians. Letter no. 31. http://www.xmission.com/~drudy/mtman/html/catlin

Cepeda, G., and D. Martin. 2003. A review of case studies publishing in management decision: Guides and criteria for achieving quality in qualitative research management decision 43(6) 851-876.

Chadwick, D. 1998. Rebirth on the Great Plains. National Wildlife. American Heritage. 36:20-29.

Chan, K.Y. and D.P. Heenan. 1996. The influence of crop rotation on soil structure and soil physical properties under different tillage and crops. Soil Tillage Res. 28:301-314.

Cheville, N.F., D.R. McCullough, and L.R. Paulson. 1998. Brucellosis in the Greater Yellowstone Area. National Research Council, National Academy Press, Washington, D.C.

Choquenot, D. 1991. Density-dependent growth, body condition, and demography in feral donkeys: Testing the food hypothesis. Ecol.72(3): 805-813.

Choquenot, D. 1998. Testing the relative influence of intrinsic and extrinsic variation in food availability on feral pig populations in Australia's rangeland. J. Anim. Ecol.67(6) 887-907.

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

Coppedge, B.R., D.M. Leslie Jr., and J.H. Shaw. 1998. Botanical composition of bison diets on tallgrass prairie in Oklahoma. J. Range Manage. 51:379-382.

Coupland, R.T., and G.M. Van Dyne. 1979. Systems synthesis, pp. 97-106. *In*" R.T. Coupland (ed.) Grassland ecosystems of the word: Analysis of grasslands and their uses.

International Biological Programme, 18. Cambridge University Press, Cambridge, United Kingdom.

Cushman, R.C., and S.R. Jones. 1988. The Shortgrass Prairie. Pruett Publ. Co., Boulder, Colo.

Damhoureyeh, S.A., and D. C. Hartnett. 1997. Effects of bison and cattle on growth, reproduction, and abundances of five tallgrass prairie forbs. American J. of Botany. 84:1719-1728.

Danz, H.P. 1997. Of bison and man. University Press, Colorado, Niwot, CO.

Dary, D.A. 1974, Revised Ed. 1989. The buffalo book. Swallow Press/Ohio University Press, OH.

Day, T.A. and J.K. Delting. 1990. Grassland Patch Dynamics and herbivore grazing preference following urine deposition. Ecol. 71(1): 180-188.

Dyksterhuis, E.J. 1958. Ecological principles in range evaluations. Bot. Rev.4:253-272.

Eynard, A., T. E. Schumacher, M. J. Lindstrom, and D.D. Malo. 2004. Aggregate sizes and stability in cultivated South Dakota prairie ustolls and usterts. Soil Sci. Soc. Am. J. 68:1360-1365.

Fahnestock, J.T., and A.K. Knapp. 1994. Plant responses to selective grazing by bison interactions between light, herbivory and water stress. Vegetation 115:123-131.

Flores, D. 1991. Bison ecology and bison diplomacy: The Southern Plains from 1800 to 1850 . J. Amer. Hist. 78:465-485.

Fox, Michael. 2007. Oral communications. Yellowstone Quarantine Facility. Interim director, ITBC.

Frank, A.B., D.L. Tanaka, L. Hofmann, and R.F. Follett. 1995. Soil carbon and nitrogen of northern Great Plains grasslands as influenced by long –term grazing. J. Range. Manage. 48: 470-474.

Frank, D.A., and P. M. Groffman. 1998. Ungulate vs. landscape control of soil C and N processes in grasslands of Yellowstone National Park. Ecol. 79(7): 2229-2241.

Gelderman R., and J. Gerwing. 2005. Soil/water research. SDSU 2006 Progress Report. Agric. Exp. Stn. Plant Science Dept. SDSU, Brookings, SD 57007

Geist, V. 1996. Buffalo nation: History and legend of the North American bison. Stillwater, MN: Voyageur Press.

Gijsman, AJ., and R.J. Thomas. 1995. Aggregate size distribution and stability of an oxisol under legume-based and pure grass pastures in the Eastern Colombian savanna. Aust. J. Soil Res. 33:153-165.

Gollany, H.T., T.E. Schumacher, P.D. Evenson, M.J. Lindstrom, and F.D. Lemme. 1991. Aggregate stability of an eroded and desurfaced Typic Argiustoll. Soil Sci. Soc. Am. J. 55:811-816.

Grenfell, B.T., O.F. Price, S.D. Albon, T.H. Clutton-Brock. 1992. Overcompensation and population cycles in ungulates. Nature 335: 823-826.

Graham, R.C., J.O. Ervin, and H.B. Wood. 1995. Aggregate stability under oak and pine after four decades of soil development. Soil Sci. Soc. Am. J. 59:1740-1744.

Haines, F. 1970. The buffalo. University of Oklahoma Press, Norman, OK.

Hamilton, R. G. 1993. The Nature Conservancy Bison Herd. Proc. North American public bison herds symposium. Lacrosse, WI. 27-29 July, 1993.

Hartnett, D. C., A. A. Steuter, and K.R. Hickman. 1997. Comparative ecology of native versus introduced ungulates. 72-101 *In* F. Knof and F. Smason, (ed.) Ecology and conservation of Great Plains vertebrates. New York: Springer-Verlag.

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

Haynes, S. and R.S. Swift. 1990. Soil saccharide extraction and detection. J. Soil Sci. 41: 73-83.

Heitschmidt, R. K., E.E. Grings, M.R. Haferkamp, and M.G. Karl. 1995. Herbage dynamics on 2 Northern Great Plains range sites. J. Range Manage. 48:211-217.

Heitschmidt, R. K. and J. W. Stuth (eds.) 1991. Grazing management: and ecological perspective. Timber Press, Portland, Ore.

Herrick, J. E., and W. G. Whitford. 1995. Assessing the quality of rangeland soils: Challenges and opportunities. J. Soil and Water Conserv. 50:237-242.

Hiernaux P. , C.L. Bielders, C. Valentine, and S. Fernandes-Rivera. 1999. Effects of livestock grazing on physical and chemical properties of sandy soils in Sahelian rangelands. J. of Arid Environ. 41:231-245.

Hill, Cheryl. 2007. Personal oral communications. Assistant Secretary, InterTribal Bison Cooperative.

Hitchcock, A.S. 1971. Manual of the grasses of the United states. Volumes 1 and 2. Dover Publications, Inc. New York.

Hobbs, R. J. , and H. A. Mooney. 1991. Effects of rainfall variability and gopher disturbance on serpentine annual grassland dynamics. Ecology 72:59-68.

Holechek, J.L., R.D. Pieper, and C.H. Herbel. 2004. Range Management Principles and Practices. Prentice Hall, Inc. Engelwood Cliffs, NJ.

Hone, J. 1994. Feral pigs in Namadgi National Park, Australia: dynamics, impacts and management. Applied Ecology Research Group, University of Canberra, Canberra, ACT 2601, Australia.

Hornday, W. T. 1890. "The Extermination of the American Bison. Report of the United States National Museum for 1887. Washington: Government Printing Office. Available at http://www.gutenberg.org/etext17748 (verified 15 Dec 2008).

InterTribal Bison Cooperative. 2007. Traditional Uses of the Buffalo. Available at http://itbcbison.com/about.php (verified 15 Dec 2008). Rapid City, SD.

InterTribal Bison Cooperative. 2007. Available at http://itbcbison.com/techncial.php. (verified 15 Dec 2008) Rapid City, SD.

Johnson, J. R., and G. E. Larson. 1999. Grassland plants of South Dakota and the Northern Great Plains. p. 10-12. South Dakota Agric. Exp. St. Bull.566.

Jurgens, M. H. 1996. Animal feeding and nutrition 8th ed. Kendall/Hunt Publishing Company, Dubuque, IA 52004.

Karl, M.G., D.A Pyke, P.T. Tueller, G.E. Schuman, M.R. Vinson, J.L. Fogg, R.W. Shafer, S.J. Borchard, W.G. Ypsilantis, and R.H. Barrett, Jr. 2006. Soil and water indicators of the Sustainable Rangelands Roundtable. p. 121-131. *In* Aguirre-Bravo, C. Pellicane, Patrick J. Burns, P. Denver, and S. Draggan, (ed). Monitoring Science and

Technology Symposium: Unifying Knowledge for Sustainability in the Western Hemisphere Proceedings RMRS-P-42CD. Fort Collins, CO. 11 Dec 2007.

Kautz, J.E., and G.M. Van Dyne. 1978. Comparative analyses of diets of bison, cattle, sheep and pronghorn antelope on shortgrass prairie in northeastern Colorado., U.S.A. p. 438-443. *In* N.N. Hyder (ed).

Kemper, W.D. and R. C. Roseneau, 1986. Aggregate stability and size distribution. P. 425-441. *In* A. Klute (ed) Methods of Soil Analysis . Part 1. 2nd ed. Agronomy Monograph. 9: 425-441.

Klein, D.R. 1968. The introduction, increase, and crash of reindeer on St. Matthew Island. J. Wildl. Mange.32:350-367.

Knapp, A.K. 1985. Effect of fire and drought on the ecophysiology of *Andropogon gerardii* and *Panicum virgatum* in tallgrass prairie. Ecol. 66: 1309-1320.

Lacey, J. R., and H.W. Van Poollen. 1981. Comparison of herbage production on moderately grazed and ungrazed western ranges. J. Range Manage. 34 (3): 210-212.

Lame Deer, John (Fire) and Richard Erdoes. 1972. Lame Deer seeker of visions. Simon and Schuster. New York, NY.

Larson, F., and W. Whitman. 1942. A comparison of used and unused grassland mesas in the Badlands of South Dakota. Ecol. 23(4): 438-445.

Larter, N.C. , A.R.E. Sinclair, T. Ellsworth, J. Nishi and C.C. Gates. 2000. Dynamics of reintroduction in an indigenous large ungulate: the wood bison of northern Canada. Animal Cons. 3: 299-309.

(The) Lewis and Clark Journal (Abridged Edition) An American Epic of Discovery. 2003. Gary E. Moulton (ed.) Journal Excerpts from 1803 to 1806 Lewis and Clark. (September, 1804 and July, 1805). Available at http://lewisandclarkjournals.unl.edu/ (verified 15 Dec 2008). University of Nebraska Press, Lincoln, NE.

Licht, D.S. 1997. Ecology and economics of the Great Plains. Univ. of Nebraska Press, Lincoln, NE.

Mails, T. E. 1995. The mystic warriors of the Plains. Marlow & Company. New York, NY.

McHugh, T. 1972. The time of the buffalo. University of Nebraska Press. Lincoln, NE.

McNaughton, S.J. 1984. Grazing lawns: Animals in herds, plant form, and coevolution. The American Naturalist, 124(6): 863-886.

McNaughton, S.J. 1995. Ecology of a grazing ecosystem: Serengeti. Ecological Monographs. 55(3):259-294

Mduma, S.A.R., A.R.E. Sinclair, and R. Hilborn. 1999. Food regulates the Serengeti wildebeest: A 40-year record. J. Anim. Ecol. 68(6):1101-1122.

Milchunas, D.G., and W.K. Lauenroth. 1993. Quantitative effects of grazing on vegetation and soils over a global range of environments. Ecological Monographs, 63(4): 327-366.

(The) National Bison Association & BisonCentral.com. 2008. History and Mission Available at http://www.bisoncentral.com/. (verified 15 Dec 2008).

National Bison Range National Wildlife Refuge, Montana. 2007. LASAR.net. Available at http://www.lasr.net/pages/recreation.php?National%20Bison%20Range%20National%20Wildlife%20Refuge&ID=1536 . (verified 15 Dec 2008). USFWS

Norland, Jack. 2001. Bison pasture and range management for the Northern Great Plains. North Dakota Buffalo Association Newsletter. Dept. of Anim. and Range Sciences. NDSU.

North Central Research Publication No. 221 (revised). 1998. Recommended Chemical Soil Test Procedures for the North Central Region. Missouri Agricultural Experiment Station. 72 pp.

Oglala Sioux Parks and Recreation Authority. 1997. Annual Report. Kyle, SD 57752

Peden, D.G., G.M. Ban Dyne, R.W. Rice, R.M. Hansen. 1974. The trophic ecology of *Bison bison* L. on shortgrass plains. J of Applied Ecol. 11: 489-498.

Pfeiffer, K.E. 1995. Bison selectivity and grazing response of little blusestem in tallgrass prairie. J. Range Manage. 48(1): 26-31.

Pickering, Robert B. 1997. Seeing the white buffalo. Denver Museum of Natural History. Denver, CO.

Pinkerton, B. W. 1997. Forage quality. Clemson University Cooperative Extension Service Web Based Electronic Forage Fact Sheet 2. Available at http://www.clemson.edu/agronomy/grasslands/basic/forage.html. (verified Dec 15 2008).

Plumb, G. E., and J. L. Dodd. 1993. Foraging ecology of bison and cattle on a mixed prairie: implications for natural area management. Ecol. Applications 3(4): 631-643.

Pyke, D.A., J.E. Herrick, P. Shaver and M. Pellant. 2002. Rangeland attributes and indicators for qualitative assessment. J. Range Manage. 55:584-597.

Redmann, R. E. 1975. Production ecology of grasslands plant communities in western North Dakota. Ecol. Monogr. 45: 83-106.

Reeder, J.D., G.E. Schuman, and R.A. Bowman. 1998. Soil C and N changes on Conservation Reserve Program lands in the Central Great Plains. Soil and Tillage Res. 45:339-349.

Risser, P.G., E.C. Birney, H.D. and Blocke., S.W. May. 1981. The true prairie ecosystem. Hutchinson Ross Pub. Co. NY.

Rogers, D. J. 1920. Lakota names and traditional uses of native plants by Sicangu (Brule) People in the Rosebud Area, South Dakota: A study based on Father Eugene Buechel's collection of plants of Rosebud. The Rosebud Education Society, Inc. St. Francis, South Dakota.

Rorabacher, J. Albert. 1970. The American buffalo in transition: An historical and economic Survey of the bison in America. North Star Press. Saint Cloud, MN.

Sample, Michael S. 1987. Bison, symbol of the American West. Falcon Press Publishing Co., Inc. Helena, MT.

SAS Institute. 1985. SAS user's guide. Statistics, Version 5 ed. SAS Institute, Cary, NC.

Sayre, N.F. 2001. The new ranch handbook: A guide to restoring western rangelands. Quivira Coalition, Santa Fe, NM.

Scheffer, V.B. 1951. The rise and fall of a reindeer herd. Victor B. Publication: The Scientific Monthly. 3(6):356-362.

Schuman, G.E., J.D. Reeder, J. T. Manley, R.H. Hart, and W.A. Manley, 1999. Impact of grazing management on the carbon and nitrogen balance of a mixed grass rangeland. Ecol. Applic. 9:65-71.

Shaw, J.H. 1995. How many bison originally populated western rangelands? Rangelands 17:148-150.

Shaw, James H. 1993. American bison: A case study in conservation genetics. *In* Ronald Walker (ed.) Proceedings of the North American Public Bison Herds Symposium, July 27-29, 1993. Lacrosse, WI, Custer State Park, SD.

Severson, K.E. 1982. Production and nutritive value of aspen understory, Black Hills. J. Range Manage. 35(6):786-789.

Sims, P.L., J.S. Singh, and W. K. Lauenrouth. 1978. The structure and function of ten Western North American grasslands: I. Abiotic and vegetational characteristics. J. Ecol. 66(1):251-285.

Sims, P. L., and P. G. Risser. 2000. Grasslands. p. 323-256. *In* M.G. Barbour and W.F. Billings (ed.) North American terrestrial vegetation 2nd ed. Cambridge University Press, NY.

Sinclair, A.R.E. 1977. The African buffalo: A study of resource limitation. University of Chicago Press, Chicago, IL.

Steinhauer, E.M. 1994. Effects of urine deposition on small-scale patch structure and vegetative patterns in prairie vegetation. Ph.D. dissertation. University of Oklahoma, Norman.

Steinhauer, E.M., and S.L. Collins. 1995. Effects of urine deposition on small-scale patch structure in prairie vegetation. Ecology 76:1195-1205.

Steuter, A.A., E.M. Steinauer, G.L.Hill, P.A. Bowers, and L.L. Tieszen. 1995. Distribution and diet of bison and pocket gophers in a Sandhills Prairie. Ecol. Appl.5(3): 756-766.

Stohlgren , T.J., L.D. Schell, and B.V. Heuvel. 1999. How grazing and soil quality effect native and exotic plant diversity in rocky mountain grasslands. Ecol. Appl. 9:45-64.

Stubbendieck, James and Walter Schacht. 1997. Range analysis laboratory manual for Agronomy 444/844. Dept of Agronomy, College of Ag Sciences and Natural Resources, IANR University of Nebraska, Lincoln.

Turner, C.L., J.R. Kneisler, and A.K. Knapp. 1995. Comparative gas exchange and nitrogen responses of the dominant C_4 grass *Andropogon gerardii* and five C_3 forbs to fire and topographic position in Tallgrass prairie during a wet year. Int. J. Plant Sci. 156: 216-226.

Turner. C.L., T.R. Seastedt, and M.I. Dyer. 1993. Maximization of aboveground grassland production: the role of defoliation frequency, intensity, and history. Ecol. Appl. 3: 175-186

Turner, Ted. 2007. Ted Turner Enterprises, Inc. Available at http://tedturner.com/enterprises/ranches.asp. (verified 13 Feb 2009).

USDA, CSREES and Tribal Colleges Research Grants Program. 2003. Northern Plains 1862/1994 Land Grant Institutions bison research collaborative. Final Report. Washington, DC.

USDA, Natural Resources Conservation Service. 2001. Rangeland Soil Quality-Aggregate Stability. Soil Quality Information Sheet. Rangeland Sheet 3. Washington, DC.

USDA, Natural Resources Conservation Service. 2001a. Soil Quality Information Sheet. Rangeland Sheet 3. Washington, DC.

USDA Agricultural Research Service and Natural Resources Conservation Service. 1998. Soil quality kit guide. Washington, DC.

Vinton, M.A., and D.C. Hartnett. 1992. Effects of bison grazing on *Andropogon gerardii* and *Panicum virgatum* in burned and unburned tall grass prairie. Oecologia.90(3):374-382.

Vinton, Mary Ann, David C. Hartnett, and Elmer J. Finck. 1993. Interactive effects of fire, bison (*Bison bison*) grazing and plant community composition in tallgrass prairie. Am.Midl.Nat. 129(9):10.

Walker, James R. 1991. Lakota belief and ritual, pp. 138-39. University of Nebraska Press. Lincoln, NE.

Wallace, L.L. , M.G. Turner, W.H. Romme, R.V. O'Neill, and Yegang Wu. 1995. Scale of heterogeneity of forage production and winter foraging by elk and bison. Landscape Ecol.10(2):75-83.

Weaver, J.E. 1968. Prairie plants and their environment. A fifty-year study in the Midwest. University of Nebraska Press, Lincoln.

Wiermann, C., R. D. Werne, R. Horn, J. Rostek, and B. Werner. 1999. Stress/strain processes in a structured unsaturated silty loam Luvisol under different tillage treatments in Germany. Soil Tillage Res. 53:117-128.

Wildlife Conservation Society. May 2007. Working Paper No. 30. Ecological future of bison in North America: A report from a multi-stakeholder, transboundary meeting. Kent H. Redford and Eva Fearn (ed.)

Yin, Robert K. 2003. Case study research design and methods. 3rd Ed. Applied social research methods series. Vol. 5, SAGE Publications, International Education and Professional Publisher, London.

Zontek, Ken. 1995. Hunt, capture, raise, increase: The people who saved the bison. Great Plains Quarterly 15:133-49.