Jackson Bison Herd (B101)
Brucellosis Management Action Plan

Wyoming Game & Fish Department

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SUMMARY

This Brucellosis Management Action Plan (BMAP) specifies management strategies regarding brucellosis in the Jackson Bison Herd. The Wyoming Game & Fish Department (WGFD) also has developed a Plan for the Absaroka Bison Management Area, and Plans for each elk herd in the Jackson-Pinedale Region containing winter elk feedgrounds. These Plans should continue to play an important role in the state of Wyoming maintaining its current brucellosis class-free status.

The objectives of this BMAP are to 1) document and analyze all available quantitative and qualitative data regarding brucellosis in bison, 2) use available data to develop management actions to reduce risk of brucellosis transmission among bison and from bison to cattle, and 3) select appropriate management actions for implementation in the Jackson Bison Herd.

The Jackson Bison Herd Area is defined as "All lands within Lincoln, Sublette, Fremont and Teton Counties west of the Continental Divide, excluding Grand Teton National Park, John D. Rockefeller Jr. Memorial Parkway, Yellowstone National Park and the National Elk Refuge". However, bison only occupy a small portion of that area, primarily wintering on the National Elk Refuge (NER) and spending the remainder of the year in Grand Teton National Park (GTNP) south of Moran Junction.

Previous management plans have been developed for the Jackson Bison Herd. Most recently, the NER and GTNP completed a Bison and Elk Management Plan and Environmental Impact Statement (BEMP-EIS) to guide management of both bison and elk on their respective lands. The BEMP-EIS thoroughly considered brucellosis, along with other wildlife diseases, in developing its set of alternatives. Thus, the WGFD's bison BMAP will incorporate some recommendations already outlined in the BEMP-EIS.

The fundamental management recommendation for the Jackson Bison Herd is to manage bison numbers, minimizing bison dispersal and the risk that bison using areas outside their established seasonal ranges will instigate conflicts with cattle and private property. The WGFD will continue to work with the Wyoming Livestock Board (WLSB) to keep bison and cattle separated. The WGFD will work with managers on NER and Forest lands to maintain hunting pressure in order to reduce the population to objective. Once at objective, hunting pressure will be manipulated to maintain the population objective. Managing for current distribution and level of use by bison will minimize risk of disease transmission through spatial separation of bison and cattle. Reducing intra-specific densities of bison (through habitat enhancement, shorter feeding durations, feeding in fewer years) should also decrease the risk of intra-specific transmission. Reduction in the number of bison in the Jackson Bison Herd, and correspondingly in the number of bison that spend the winter on NER feedlines should help spread bison out. Less artificial concentration should help in reducing intra-specific transmission of brucellosis. Along with the eventual implementation of a vaccination program, these actions should reduce the seroprevalence of brucellosis in the bison herd over time.

This document will receive annual re-evaluation to incorporate new brucellosis research results, management protocols, and agency (state, federal, private) recommendations.

INTRODUCTION

BMAP Goal and Objectives

In February 2004, Wyoming lost its brucellosis class-free status when 31 reactor cattle were detected in a Sublette county herd (Galey et al. 2005). Infection of these cattle likely originated from elk on the nearby Muddy Creek feedground. Following this loss of class-free status, increased surveillance of Wyoming cattle revealed a series of herds with the disease in the Greater Yellowstone Ecosystem (GYE, Galey et al. 2005).

To develop management strategies regarding brucellosis in the GYE of western Wyoming and regain brucellosis class-free status, the Wyoming Brucellosis Coordination Team (WBCT) identified the BMAP process as their highest priority recommendation for reducing brucellosis transmission from elk to elk and from elk to cattle (Galey et al. 2005). Because of increased surveillance, research and BMAP development efforts, and lack of infection in cattle herds since 2005, Wyoming regained its brucellosis class-free status September 2006.

The original recommendation from the WBCT (Galey et al. 2005) stated that Wyoming would ask the U.S. Fish and Wildlife Service (USFWS), NER, and National Park Service (NPS) to develop brucellosis management plans for elk and bison similar to the WGFD BMAPs. However, in early 2007, a Record of Decision (ROD) was finalized for the BEMP and EIS authored by the NER and GTNP (USFWS and NPS 2007). The BEMP-EIS thoroughly considered brucellosis, along with other wildlife diseases, in developing its set of alternatives. Rather than request for those agencies to write a separate Brucellosis Plan, this document will incorporate recommendations already outlined in the BEMP-EIS. A shared goal of this Plan and the BEMP-EIS is to protect the economic interest and viability of the livestock industry through reducing the prevalence of brucellosis in the bison population.

The objectives of this BMAP are to 1) document and analyze available quantitative and qualitative data regarding brucellosis in bison, 2) use available data to develop management actions to reduce risk of brucellosis transmission among bison and from bison to cattle, and 3) select appropriate management actions for implementation in the Jackson Bison Herd. This plan, combined with its Appendices (1-4), include data and information relevant to understanding, formulating, and implementing management actions. This document will receive annual re-evaluation to incorporate new brucellosis research results, management protocols, and agency (state, federal, private) recommendations.

Public Involvement in this BMAP

Between 2005 and 2007, Brucellosis Management Action Plans were developed for each of seven elk herds associated with feedgrounds in the Jackson-Pinedale Region. The WGFD followed the WBCT recommendations to coordinate with producers, land management agencies, and livestock disease regulatory agencies. Opportunity for public feedback on BMAPs was given at WBCT meetings, and a public presentation was made when each was completed.

The WGFD sought to enhance public participation opportunities during drafting of the Bison BMAPs. This was accomplished by including Bison BMAP as an agenda item in the September 2007 WBCT meeting, where brief outlines of the Jackson and Absaroka Bison Herd BMAPs were presented for WBCT consideration and for public comment. The WGFD followed with its own public meetings to review draft BMAPs in Cody and Jackson during December 2007. Written public comment was accepted until January 18, 2008. Comments were taken into consideration during final revisions of the document.

Jackson Bison Herd Overview and Distribution

Chapter 41 of the Wyoming Game and Fish Commission (WGFC) Wildlife Regulations defines the Jackson Wild Bison Herd Area as "All lands within Lincoln, Sublette, Fremont and Teton Counties west of the Continental Divide, excluding Grand Teton National Park and Yellowstone National Park" (Figure 1). Chapter 15 of the WGFC Regulations defines the Jackson Bison Hunt Area (Bison Hunt Area 2), which is identical to the Herd Area.

The Jackson Bison Herd actually occupies only a fraction of the Jackson Bison Herd Area. The herd ranges primarily in Teton County. For several years, the bison herd has primarily wintered on NER, and spent the remainder of the year in GTNP (Figure 2). Bison also cross into Bridger-Teton National Forest (BTNF) lands and onto state and private lands.

Some variation has been seen over time in specific distribution of the herd, as evidenced by radio-collared animals (Cain et al. 2001, 2004, 2005). Typical movements have been for bison to move off the NER to summer ranges in GTNP during May and June. The herd has tended to concentrate in the Row Fire/Antelope Flats/Kelly Hayfields areas of GTNP for the August rut, and then move back to summer ranges for September and October.

Since 2004 bison have extensively used the area of the 2003 Blacktail Butte wildfire, especially from mid-summer through fall and early winter (Cain et al. 2004). In 2003 and 2004, more satellite groups were observed in the Potholes and Elk Ranch areas of the Park during the August rut, but the primary rutting continued to take place in Antelope Flats. Also in 2004, the NER had record high forage production, and large groups (over 100) of bison were seen on the Refuge as early as August.

In early winter, large groups of bison can be found on both NER as well as summer/transitional ranges in GNTP, especially the Elk Ranch area. During some winters, groups of up to 100 bison have stayed in the Elk Ranch area, at least until March when they leave for the NER.

History of the Herd

Bison were reintroduced to the Jackson area in 1948 when 20 animals from YNP were put in a holding facility at the Jackson Hole Wildlife Park at Moran. Management of the Park was primarily the responsibility of the WGFC until the expansion of GTNP in 1950. At that time, management of the Park began shifting to the NPS. Throughout the 1960s, management actions were coordinated with the WGFD and included winter feeding, capturing bison that escaped (which occurred several times annually), and routine brucellosis testing and vaccination (WGFD 2005). Herd size varied from 15-30 until 1963 when brucellosis was documented in the herd. Thirteen adults were removed from the herd, leaving just four yearlings. The yearlings, which had been vaccinated, were retained, along with five new calves that were also vaccinated.

In 1964, 12 certified brucellosis-free adults (6 males and 6 females) were obtained from Theodore Roosevelt National Park in North Dakota, bringing the total number to 21. By 1968 the population had declined to 11 adults (all testing negative for brucellosis) and 4 or 5 calves. Later that year the entire herd escaped the confines of the Wildlife Park. Efforts to recapture the bison were unsuccessful; six were caught, six were killed, and three spent the winter on the NER. Since the winter of 1969-70 the bison have been allowed to range free.

From 1969-1976 the population averaged 14 animals. The bison wintered within GTNP until 1975, when they moved to the NER. By 1980 bison were taking advantage of the supplemental feed intended for the elk. The bison readily adapted to the situation, as they had no

trouble displacing elk from the feedlines. Subsequently, the population started to grow rapidly. Jackson bison have wintered primarily on the NER ever since. Refuge personnel have provided separate feedlines for bison since 1984 to minimize conflicts between bison and elk.

Aside from periodic agency removals to control brucellosis, public take in the Jackson herd had been limited. During the winter of 1974-75 two bulls were killed on a private inholding in GTNP by a landowner (Wood 1975). During the winter of 1983-84 NER personnel killed five bulls that had gored federal government horses and were deemed a threat to Refuge visitors. Two bison were shot on the Twin Creek Ranch adjacent to the NER in 1987. A single bull was shot on private land near Marbleton, Wyoming in 1988.

Previous Management Plans

A joint Environmental Analysis (EA) on the bison herd was completed in December 1987 by the NER and GTNP. This EA by the Interagency Bison Management Technical Group (IBMTG: USFWS, NPS, WGFD, U.S. Forest Service [USFS]) evaluated several management options for the herd and opted to manage for a population of 50 animals. At the time, this meant that 50-60 animals would need to be removed. The EA was not well accepted by the public.

Due to public outcry the agencies instead developed an Interim Management Plan that would maintain the herd in the range of 90-110 animals. That plan was intended to cover the five-year period ending December 1994. A requirement of the Interim Management Plan was that the agencies adopt an Annual Interagency Bison Management Program to cover each year for the five-year period. Under that system, reductions were accomplished by Agency personnel in the winter of 1988-89 and by hunters in 1989-90 and 1990-91.

In early 1989, 16 bison were culled from the NER- leaving 105 animals in the herd. During the summer of 1989, the WGFC established a Hunt Area (Figure 1) for the herd and the Wyoming legislature approved license fees and altered the laws governing the taking of bison in Wyoming. That fall the first hunt, conducted as a special permit sport hunt administered by the WGFD, took place on the NER. Hunters killed 19 bison during the 1989-90 season. At the time, WGFD personnel accompanied hunters in the field, designated which bison were to be harvested, and collected tissue and blood samples from harvested animals. In 1989 the Wyoming Coop (Shelley and Anderson 1989) provided the agencies with a review of proposed management options and recommendations on how management options would affect short-term genetic variation and viability. Data from the 35 animals taken in 1989-90 indicated a high degree of genetic variation, and that seroprevalence for brucellosis was around 70% (WGFD 1991).

The 1990-91 Annual Interagency Bison Management Program once again called for a small herd reduction. However, in the fall of 1990, Legal Action for Animals filed a lawsuit before the 12-animal reduction in 1990-91 could take place. Prior to the court injunction, 2 hunters harvested bison. A court agreement halted all bison reductions until completion of an EA and approved long-term management plan for the Jackson herd.

In 1997 the NPS and USFWS, along with WGFD and USFS as cooperators, completed the *Jackson Bison Herd Long-term Management Plan and Environmental Assessment*. The preferred alternative identified several mechanisms for minimizing transmission from bison to livestock, including: 1) limiting herd size and maintaining herd objective through culling, 2) separating bison from elk on feedlines, 3) using a safe and effective brucellosis vaccine on bison, 4) working with livestock producers to increase spatial and temporal separation of bison and livestock, and 5) developing risk assessment models to better focus management actions. The

mechanism for herd reduction was to be public hunting on the NER and BTNF. At that time, the population had increased to over 300 animals, and the WGFC set the herd objective at 350-400. Before the plan was fully implemented, the Fund for Animals sued in 1998 to prevent "destructive management" of bison until the effects of the Refuge's feeding program on bison were more fully analyzed. The WGFD continued to regulate bison hunting on BTNF lands, but annual harvest was not been enough to control the population. Without hunting on the Refuge, the bison population continued to increase rapidly.

Bison and Elk Management Plan and Environmental Impact Statement

In order to satisfy requirements of the court injunction and the National Environmental Protection Act (NEPA), GTNP and the NER assembled the BEMP and associated EIS over the course of several years. The process was initiated in 1999, a draft of the BEMP-EIS was completed in 2005, and the Record of Decision was completed for the BEMP-EIS in the spring of 2007 (USFWS and NPS 2007). Alternative 4 was selected as the management approach, to "adaptively manage habitat and populations to achieve desired conditions over 15 years".

Four goals guided the creation of the BEMP: 1) habitat conservation, 2) sustainable populations, 3) numbers of elk and bison, and 4) disease management (USFWS and NPS 2007). Major elements of the chosen alternative are:

- Habitat restoration of native and cultivated areas
- Minimize bison and elk conflicts with adjacent landowners
- Public education
- Identifying criteria for beginning and ending feeding on the NER
- Transition from supplemental feeding to greater reliance on standing forage
- Maintain bison and elk numbers
- Permit WGFD to vaccinate elk and bison on the NER

The BEMP emphasizes cooperation with agency partners on several of the elements. In turn, there are aspects of WGFD management of the bison herd that interrelate with the BEMP. The Refuge and Park contribute substantially to the bison herd and the effects that the herd has on surrounding habitats, thus the BEMP-EIS contributes to the herd objectives set by WGFD. The EIS recommends a population objective, but the final objective requires a public input process and a final WGFD recommendation to be approved by the WGFC. Thus, the final EIS states the NPS and USFWS would work with the WGFD in developing a population objective to be approved by WGFC. In March 2008 the WGFC adopted a bison population objective of 500, in concert with the BEMP-EIS.

Many other areas of management require cooperation between WGFD and other agencies. Some of those areas are highlighted in this document.

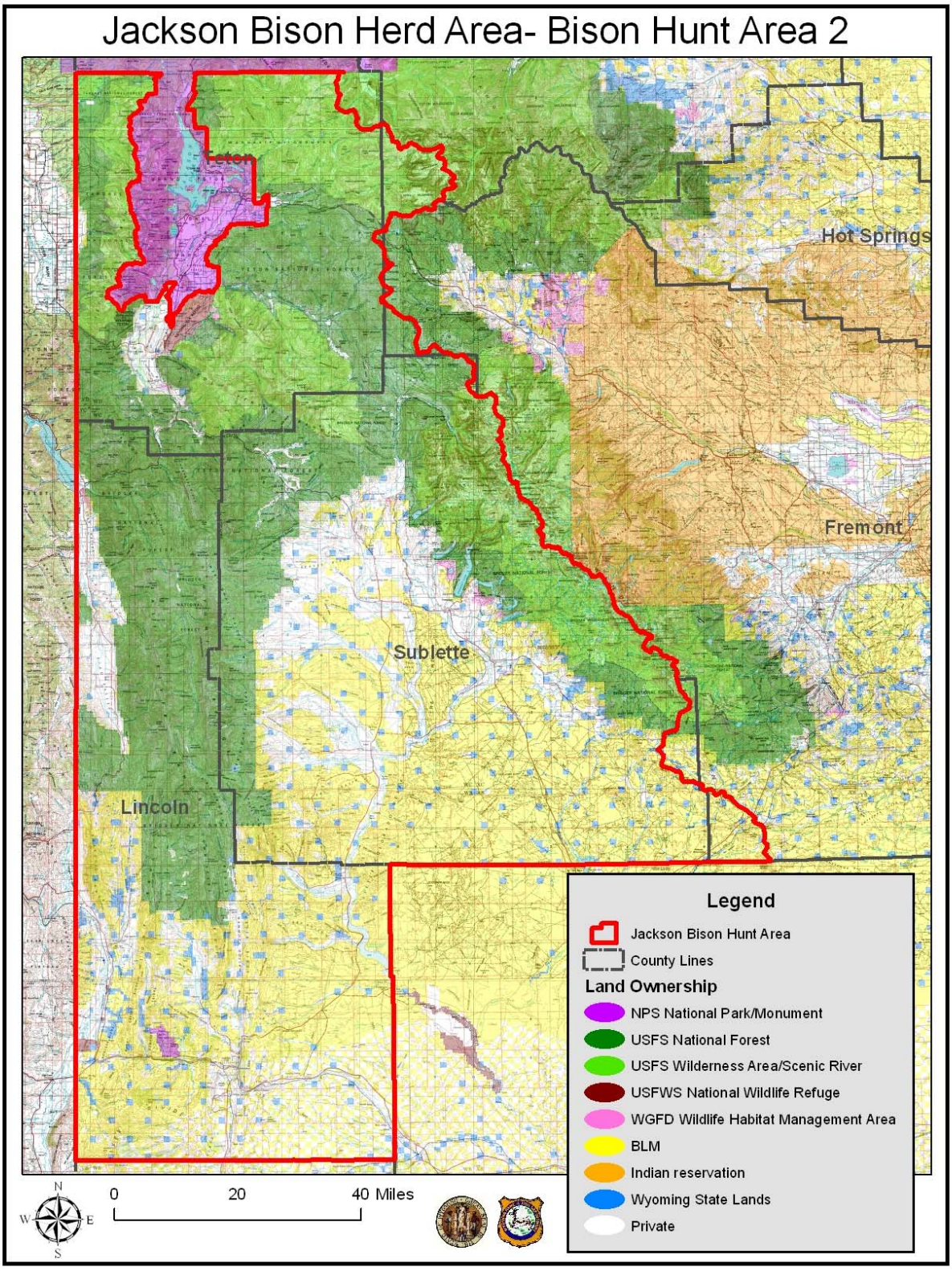

Figure 1. The Jackson Bison Herd Area. Hunt Area 2 for bison, Jackson, is identical to the Jackson Bison Herd Area.

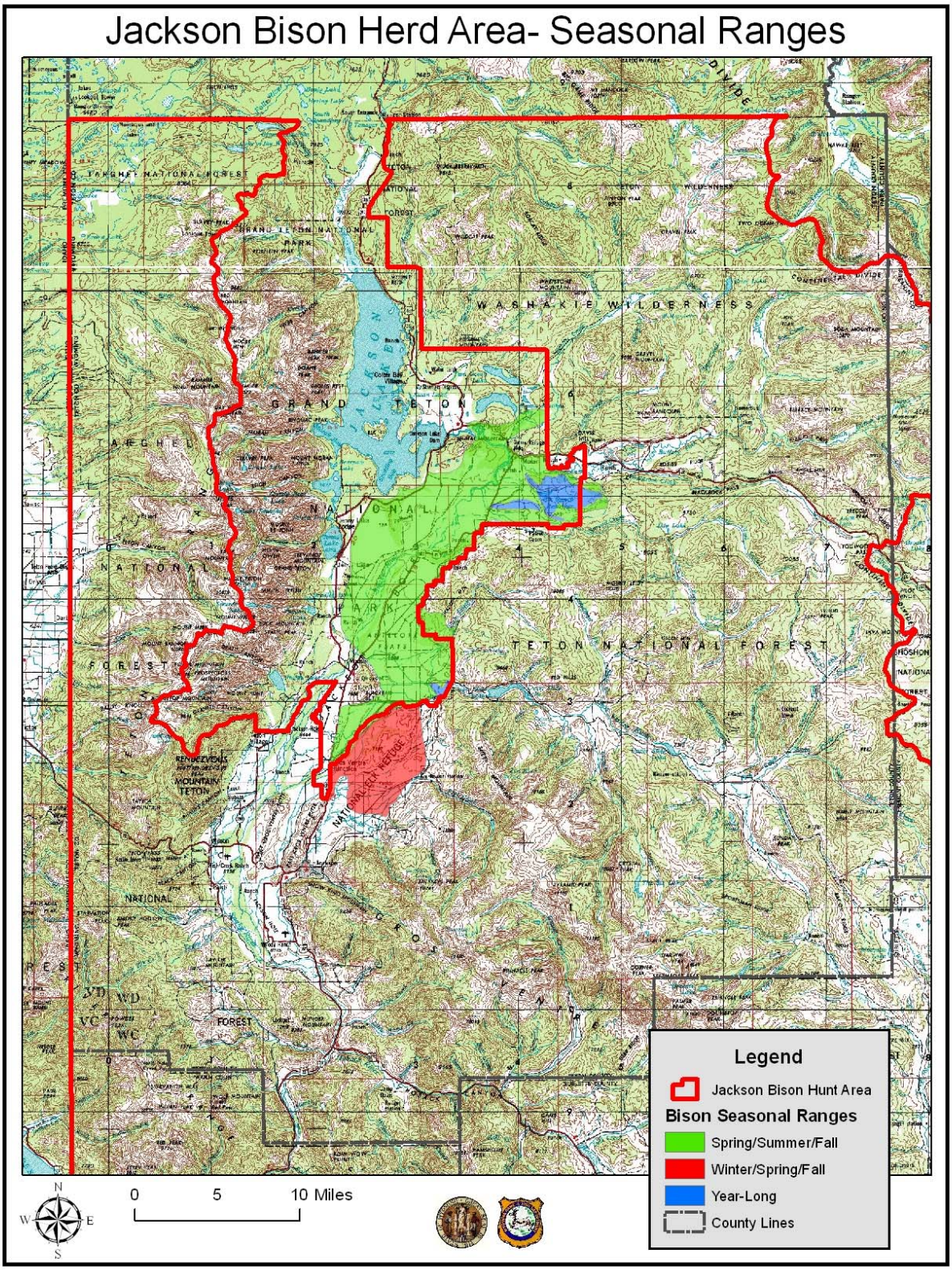

Figure 2. Seasonal distributions of the Jackson Bison Herd.

BIOLOGY AND MANAGEMENT

Bison and Brucellosis

Brucellosis, caused by infection with the bacterium *Brucella abortus*, has sparked controversy because of its persistence in elk (*Cervus elaphus*) and bison (*Bison bison*) of the GYE of Wyoming, Montana, and Idaho (Thorne et al. 1978) and potential threat to domestic livestock (Kistner et al. 1982). Presumably, *B. abortus* was transmitted from domestic livestock to free-ranging bison and elk just prior to 1917 (Meagher and Meyer 1994) after repetitive commingling and subsequent contact with aborted fetuses contaminated with brucellosis. Subsequently, brucellosis was isolated from free-ranging bison (Mohler 1917) and elk (Rush 1932) of western Wyoming in 1917 and 1931, respectively.

Brucella transmission usually occurs via the oral route, with ingestion of bacteria that are shed by infected females in high numbers in aborted fetuses, fetal membranes and fluids, or uterine discharges (Thorne 1982, Cheville et al. 1998). The role of lactation in brucellosis transmission is unknown (Gross et al. 2002), but Meyer and Meagher (1995) hypothesized that excretion of *B. abortus* throughout most or all of the lactation period was a reasonable explanation for high infection rates seen among subadult bison. Infection usually results in reproductive failure (abortion of the first pregnancy) and other clinical syndromes such as retained placenta, thickened and leathery placenta, necrotic cotyledons, vaginal discharge, metritis, and possible sterility (Thorne 1982, Jubb et al. 1985 cited by Meyer and Meagher 1995). In males, the consequences can include epididymitis, orchitis, seminal vesiculitis, and possible sterility (Manthei and Deyoe 1970 cited by Meyer and Meagher 1995).

Researchers rely on detecting antibodies in the bloodstream to determine the prevalence of brucellosis in wildlife. To determine the serostatus of bison, the following five tests are used: 1) Card test, 2) Standard plate agglutination (SPT) test, 3) Complement-fixation (CF) test 4) Rivanol test, and 5) the fluorescent polarization assay (FPA). An animal is considered "seropositive" if 1) either two or more tests react at certain dilution rates, or 2) if the CF test alone shows a reaction at a dilution rate of 2+ 1:20 or higher. The criteria used to determine what is called a positive reactor (positive) for the five serology tests is as follows: 1) Card – positive or negative (no dilution), 2) SPT – 1:100 dilution or greater, 3) CF – 2 + 1:20 dilution or greater, 4) Rivanol – 1:25 dilution or greater, 5) FPA – positive or negative (no dilution). Killing the animal(s) and culturing Brucella from host tissues determines actual infection.

Researchers have tested Jackson bison for brucellosis seroprevalence levels assorted times in recent decades (*see* Brucellosis Surveillance, page 19). Twenty-eight of 35 (80%) adult bison in the Jackson herd tested from 1989 to 1990 tested positive for antibodies (Williams et al. 1993). Williams et al. (1993) went on to perform culture tests on several tissues from 4 of the seropositives; 2 of those 4 were culture positive. Most bison harvested by hunters since 1999 have been tested as well. Through the 2007 hunting season 489 usable blood samples had been obtained from harvested animals. Sixty-four percent of males (n = 169/263) tested seropositive, and 59% of females (n = 134/226). Knowing the serology of adult cows specifically is most useful because abortion by females and subsequent contact with infected materials by susceptible animals is the most likely route of transmission.

Elk in northwest Wyoming, primarily those associated with winter feedgrounds in the Jackson area, also carry brucellosis. Surveillance on feedgrounds in the Jackson Elk Herd typically occurs January through March. Based on cELISA and multiple years of data, seroprevalence levels range from 17% to 42% on state-operated feedgrounds in the Gros Ventre

valley (WGFD 2007). Seroprevalence on the NER is estimated to be 16% based on cELISA testing since 1997. Caution must be exercised when considering the validity of seroprevalence data; often the sample size obtained is below what is needed for an 85% confidence level.

Infection rates of bison are part of determining the level of risk that bison might abort, thus potentially transmitting *Brucella*. The gestation period of bison, in turn, determines the period of exposure *when* bison could potentially abort and spread the bacteria. Of special concern is the third trimester of bison pregnancy (U.S. Dept. of Interior and U.S. Dept. of Agriculture 2000). The WLSB has defined the "period of exposure" for cattle as 1 January to 1 May (WLSB 2006). According to the Brucellosis Exposure Policy, exposure has occurred when cattle have been subject to 24 hours of continuous exposure or 72 hours of intermittent exposure between January 1 and May 1. This applies to areas where testing has shown a 3% or greater seroprevalence in wildlife.

Timing of parturition among bison of the GYE seems to vary by location and year (Gogan et al. 2005, Berger and Cain 1999). Meagher (1973) reported that most calves in the YNP herd are born during a 6-week period from mid-April to the end of May. Gogan et al. (2005) suggested the majority of YNP bison parturition dates were in April and May, with a small percentage occurring through the summer; they found that median birth dates for YNP bison over a period of recent years ranged widely, from 28 April to 22 May. Median birth dates varied between the Northern and Central herds, probably because of the earlier onset of the growing season leading to higher nutrition and thus earlier birth dates for the Northern herd. Timing and duration of parturition periods might depend largely on temporal variation in the quantity and quality of food, affecting nutrients available to mothers and offspring; thus the length of the birth season generally varies with the length of the growing season (Green and Rothstein 1993). Thus, the extent and timing of parturition in bison can be expected to vary across years.

Median birth dates reported for the Jackson bison herd have been 20 May, 23 May (Berger and Cain 1999), and the first week of June (Cain et al. 2005, Fig. 3) Berger and Cain (1999) found that 95% of births in the Jackson bison herd had occurred by the end of June (n = 52 births). With a larger sample size (n = 125) spread over several years, Cain et al. (2005) determined that 90% of calving was completed by the end of July, but that 95% was not complete until almost September; one birth occurred the first week of December. Berger and Cain (1999) suggested that brucellosis-infected females might abort early in pregnancy and conceive again late in the same breeding season, thus extending the calving season by birthing later than non-aborting bison.

Because bison can calve throughout the year and they do come in relatively close contact with cattle, they are an important potential source of brucellosis to cattle. Experimental *B. abortus* infections in captive bison have produced abortions and transmission to cattle under controlled conditions (Davis et al. 1990), and there has been one documented case of bison to cattle transmission in confined ranching conditions (Flagg 1983). However, there is no documentation that transmission from free-ranging bison to cattle or to humans has ever occurred (Meyer and Meagher 1995), and few *Brucella*-induced abortion events in bison in the GYE have been documented (Mohler 1917, Williams et al. 1993, Rhyan et al. 1994, Clarke et al. 2005). Still, bovine infection and loss of the brucellosis-free status by Wyoming due to bison (or elk) could cause wildlife directed resentment by many Wyoming stockgrowers. Thus, a critical component in any brucellosis management plan is spatial-temporal separation of *Brucella*-infected wildlife from cattle, and vice versa.

BRUCELLOSIS MANAGEMENT ACTIONS

WGFD Management Goals for the Jackson Bison Herd, along with specific strategies to reach those goals:

1. Reducing the population of the bison herd, and subsequently maintaining the herd at population objective.
   - Recommend an increase from 350-400 for the bison population objective to 500.
   - Continue recreational hunting seasons to ensure adequate hunting opportunity to maintain the population objective.
2. Maintain habitat.
   - Cooperate with land management agencies within the range of the Jackson Bison Herd to develop and implement habitat treatments.
   - Allow bison to occupy any habitats where they do not conflict with livestock and residential areas.
3. Minimize risk of transmission from bison to cattle by maintaining spatial and temporal separation of bison and domestic cattle.
   - Monitor bison and cattle distributions and work with affected publics and agencies.
   - Utilize hunter harvest or Department removal of bison from potential commingling situations.
   - When necessary, agency personnel will either haze or lethally remove bison from commingling situations.
   - Continue working with the WLSB to prevent bison/cattle commingling.
   - Recommend fencing to protect cattle from commingling with bison, where appropriate.
4. Vaccinate bison with strain RB51, or a more efficacious vaccine if one is developed.
   - Reduce the proportion of female bison becoming infected and aborting.
   - Reduce overall seroprevalence in the herd.

The fundamental management recommendation for the Jackson Bison Herd is to manage bison numbers, minimizing bison dispersal and the risk that bison using areas outside their established seasonal ranges will instigate conflicts with cattle and private property. The WGFD will continue to work with the WLSB to keep bison and cattle separated. WGFD will work with managers on NER and Forest lands to maintain hunting pressure in order to reduce the population to objective. Once at objective, hunting pressure will be manipulated to maintain the population objective.

Managing for this distribution and level of use by bison will minimize risk of disease transmission through spatial separation of bison and cattle. The WGFD should also work to minimize the likelihood that bison moving from winter range on the NER to summer range in GTNP or BTNF would commingle with cattle on private lands. There is also the need to minimize the likelihood that bison will overlap with cattle on federal grazing allotments in GTNP or BTNF.

Reducing intra-specific densities of bison (through habitat enhancement, shorter feeding durations, feeding in fewer years) might also help decrease the risk of intra-specific transmission. Reduction in the number of bison in the Jackson Bison Herd, and correspondingly in the number of bison that spend the winter on NER feedlines should help spread bison out. Less artificial

concentration should help in reducing intra-specific transmission of brucellosis. Along with the eventual implementation of a vaccination program, these actions should reduce the seroprevalence of brucellosis in the bison herd over time.

Specific actions to be taken by WGFD to achieve the management goals for bison in the Jackson Bison Herd are described below. Some of these strategies have already had elements in place.

Bison Population Reduction and Maintenance of Herd Objective

Documented problems with bison overabundance include habitat damage, competition with elk for native forage, increased cost of supplemental feeding, human safety concerns, and damage to private property.

Increased hunter take of bison in the Jackson Herd, along with reductions in the frequency and duration of feeding on the NER as outlined in the BEMP-EIS (USFWS and NPS 2007) should reduce the population to approximately 500. Harvest objectives will be higher in the next few years than in the long term. Allowing hunting on the NER is already helping to increase the harvest of bison (Appendix 1). About 70-90 bison per year would need to be harvested to maintain the herd around 500 once that number is reached.

As the Jackson Bison Herd is reduced, the chance of bison dispersing broadly outside of their established seasonal ranges and instigating new conflicts on private lands should be diminished. Decreased density of bison could also help to reduce bison's duration on feedlines, as more natural winter range will be preserved. Less time on feedlines and lower densities of bison on feedlines might decrease the potential for transmission of *B. abortus* bacteria among bison. Feeding expenditures will also be reduced.

The WGFD will continue to design and implement harvest strategies to ensure the bison population is maintained at the established Herd Unit objective. The WGFD will continue to work cooperatively with managers from the NER, GTNP, and BTNF on maintaining the bison objective.

Habitat Enhancement

While elk require artificial concentration (i.e., feeding), or periodic re-exposure to infected tissues from elk, bison, or cattle (e.g., YNP elk) to perpetuate brucellosis (Cheville et al. 1998), bison apparently are more efficient at intraspecifically transmitting the disease and can maintain it without winter feeding (e.g., YNP bison). However, the winter feeding program at the NER probably contributes to the exceptionally high seroprevalence among the Jackson bison (Smith 2005, GYIBC 1997).

Affecting bison distribution through habitat manipulation can be positive on multiple fronts. First, habitat enhancement projects might reduce the time bison spend on the NER by decreasing bison's dependence on artificial feed. Second, habitat enhancements could be planned so they will prevent bison commingling with cattle.

Prescribed burns and wildfires occurring within the range of the Jackson Bison Herd or close to it have been shown to alter bison distribution (Appendix 2). Bison have promptly been attracted to the increased amount and quality of forage created by burns in grassland and sagebrush.

Habitat enhancement projects should be carefully planned so they will prevent, rather than encourage, commingling. Habitat enhancement projects that will increase forage production in and near current bison seasonal ranges should be critically examined for overlap

with cattle allotments and cattle on private land. Cattle allotments in GTNP will have to continue to be managed to keep bison and cattle away from each other (Appendix 3). The WGFD will work cooperatively with Park and Forest personnel to develop grazing regimes and habitat enhancement proposals. The WGFD will continue to allow bison to occupy any areas where they do not conflict with livestock and residential uses.

The NER will emphasize an increase in the amount and quality of forage through prescribed and wildland-fire, modifications to the flood irrigation system, and adding to the sprinkler irrigation system (USFWS and NPS 2007). GTNP management habitat management will result in 4,500 acres of agricultural lands being restored to native grasslands and shrublands. Periodic prescribed fire would be necessary to maintain herbaceous production, otherwise areas will tend towards sagebrush. As native grasses are restored to the Kelly hayfields, Mormon Row, and Hunter-Talbot areas, these restored agricultural lands could provide relief to ranges on the NER in both spring and fall.

Implementation of bison reduction would facilitate habitat enhancements. Habitat enhancement projects that set back succession work best when rested from grazing pressure afterward. The most logistically and financially feasible means of resting treatments from wild ungulate use is through coordinated harvest strategies.

Habitat enhancements and wildfires have demonstrated their effects on temporal and spatial bison distribution. Thus, they are effective in altering distribution, and when combined with harvest strategies can be effective in attaining/maintaining population objectives. However, because of brucellosis transmission mechanisms and the gregarious behavior of bison, habitat enhancements and complete bison dependency on native winter range would not eliminate brucellosis from this species as it might in elk.

Habitat enhancement projects should benefit many species of vegetation and wildlife in addition to bison. WGFD will continue to coordinate with private landowners, federal land managers, and livestock permittees to develop and implement habitat improvements that may reduce bison dependency on supplemental feed (Appendix 2). The WGFD will emphasize coordination among NER, BTNF, GTNP, and WGFD through the Jackson Interagency Habitat Initiative (JIHI).

Spatial-Temporal Separation of Bison and Cattle

Management actions should maintain spatial and temporal separation of bison and cattle during the brucellosis transmission period (January-May, WLSB 2006). Strategies include hazing or removing bison from cattle during the transmission period as well as preventing livestock use of bison ranges until after June 15, an allowance for the time that *Brucella* could persist at bison parturition or abortion sites (Aune et al. 2006).

Timing of cattle grazing on BTNF and GTNP grazing allotments can and should be manipulated to assure temporal and spatial separation of bison and cattle until after most bison have calved. Because bison do not occupy much area outside of GNTP and the NER, potential for overlap with public grazing allotments is limited. There are no occupied public grazing allotments where bison typically occur on BTNF lands. There are no cattle grazing allotments on BTNF land adjacent to the Refuge. If bison maintain their current seasonal ranges, no additional areas of spatial or temporal overlap with cattle will take place.

There is potential for bison and cattle overlap in GTNP. However, the NPS has developed an elaborate system of grazing management to ensure spatial and temporal separation

of bison and cattle (Appendix 3). GTNP also requires cattle placed on those allotments to be vaccinated for brucellosis.

The WGFD will work with cattle producers and other agencies (e.g., NRCS, BTNF, GTNP) in the Jackson area to implement any changes to their operations that decrease the risk of disease transmission from wildlife. In addition, WGFD and WLSB have already outlined regulations for removing bison that are a threat to cattle (*see* Coordination with WLSB, page 16).

Bison Vaccination with Strain RB51

Multiple tools will be needed to reduce seroprevalence of brucellosis in the Jackson Bison Herd. While the specific response of seroprevalence in bison when the population is reduced is unknown, it is unlikely to be reduced to an acceptable level assuming the remaining bison are still fed in the winter.

The ROD for the BEMP-EIS states that the WGFD would be permitted to vaccinate bison for brucellosis on the NER as long as it is logistically feasible, but NER management actions would not be specifically designed to facilitate vaccination (i.e., vaccination would not be the impetus to start or continue feeding operations). Strain RB51 has been determined safe and efficacious for use in bison (Appendix 4). A remote-delivery method that delivers the optimal amount of vaccine to the greatest number of bison is still being developed.

The WGFD will continue to work on developing a plan for bison vaccination that would be suitable for implementation on the NER. Biobullet technology has not yet been developed that would effectively and consistently deliver an appropriate dose of RB51 to bison. Full-scale vaccination of all calves, female yearlings, and adult cows is not feasible immediately with existing technologies and resources.

While the method of delivery is being improved, it is possible that other, more efficacious vaccine strains could be developed. Any bison vaccination program WGFD implements would be adaptive in using the best available delivery method with the best available vaccine.

COORDINATION WITH AGENCIES AND CATTLE PRODUCERS

Inter-Agency Meeting

A meeting was held November 29, 2007 with representatives attending from the WLSB, APHIS-VS, NER, BTNF, and hosted by WGFD. Communications also took place with personnel from GTNP. The intent of the meetings was to provide an overview of the bison BMAP so far developed by WGFD, and take input from those other agencies.

Drafts of this plan were made available to cooperating agencies prior to the inter-agency meeting, and prior to the public meeting held on December 19, 2007.

Wyoming Livestock Board

The WGFD and the WLSB have cooperatively developed criteria to deal with bison that leave the established Herd Units (Absaroka and Jackson) and pose a threat to livestock. The WGFC and the WLSB created Chapter 41 of their respective regulations to designate bison found in the Absaroka wild bison management area and Jackson wild bison herd area as wildlife. Chapter 41 of the WGFC Regulations goes on to regulate the removal of privately-owned bison, and the removal of wild bison. Privately-owned bison running at large outside of the Absaroka wild bison management area or Jackson wild bison herd area shall be removed by the owner within 48 hours of a request from the Livestock Board.

Privately-owned bison at large within the Absaroka management area or Jackson bison herd area also shall be removed by the owner within 48 hours of a request from the WLSB. If a privately-owned bison is suspected of having been exposed to wild bison infected with brucellosis, quarantine and testing of the privately-owned bison will be done to ensure the bison is brucellosis free.

Section 8 of Chapter 41 outlines the removal of wild bison within the Absaroka and Jackson areas through hunting seasons. If wild bison pose a health threat to livestock, as determined by the WLSB, the WLSB may order WGFD to remove the wild bison immediately. Chapter 41 does not specify a time of year (period of exposure) when this applies, only that a health threat to livestock is determined by the WLSB or its designee. Additionally, WGFD may remove a wild bison immediately if it poses an immediate threat to public safety.

APHIS-VS

Both APHIS-Veterinary Services (VS) and the WLSB have been working with cattle producers to develop individual ranch herd plans to mitigate the risks of commingling with bison or elk. These individual herd plans are analogous to the BMAPs the WGFD was charged with writing for bison and elk herds. Personnel with APHIS-VS have also provided technical assistance and advice to the WGFD in the drafting of the elk and bison BMAPs.

National Elk Refuge

The WGFD and NER coordinate on several aspects pertinent to the Jackson Bison Herd. Coordination between the WGFD and NER will continue to play a critical role in maintaining the bison herd at objective through allowing hunting opportunities. The WGFD and NER will also continue to coordinate on the potential for a vaccination program for bison.

A Cooperative Agreement between the WGFD and the NER is in the process of being updated. The last Cooperative Agreement between the two agencies was completed in 1974 (USFWS and WGFD 1974)- mutual concern over bison management has built since then. Elements of the new agreement should deal with elk and bison hunting, feeding of both species, numbers of both species, vaccination, habitat conditions, and research.

Grand Teton National Park

While there is potential for bison and cattle to overlap in GTNP, Park personnel, not the WGFD, deal with those issues. GTNP has developed a system of grazing management that ensures spatial and temporal separation of bison and cattle on their public grazing allotments (Appendix 3). GTNP also requires cattle to be vaccinated; the requirement for vaccination is included in the individual Special Use Permit issued to each producer on an annual basis.

Personnel from GTNP also coordinate on habitat issues as part of the Jackson Interagency Habitat Initiative (JIHI). The group was formed in the fall of 2001 by several wildlife biologists from the BTNF, NER, WGFD, and GTNP. A driving force in the formation of the group was concern over the loss of habitat effectiveness on native ungulate winter and transitional ranges within the Upper Snake River Basin (USRB) and the challenges the agencies faced in implementing on-the-ground habitat enhancement projects. Habitat enhancements spread throughout watersheds of the USRB should encourage a wide distribution of both elk and bison, reducing disease risks.

Bridger-Teton National Forest

The WGFD will continue to request cattle allotment information from the BTNF. Knowing the status of grazing allotments on forest lands will allow WGFD personnel to assess risk of bison-cattle commingling, and deal with it in an effective manner.

Personnel from the BTNF also coordinate on habitat projects through JIHI. The WGFD also will continue to communicate with managers from the BTNF on bison hunting occurring on forest lands.

Natural Resources Conservation Service

The NRCS has enabled the use of Environmental Quality Incentives Program (EQIP) funding as financial incentive for producers involved in brucellosis mitigation in Teton, Lincoln, and Sublette counties. Producers would be eligible for financial incentives contingent on implementation of their individual ranch herd plan (with the assistance of APHIS-VS and the WLSB, above). Thus, NRCS has the potential to become an available source of funding for mitigation projects where brucellosis concerns are the impetus. The EQIP funding could be used by producers for a variety of projects (e.g., implementing their best management practices, corral improvement, adult vaccinations, annual bleeding, building wildlife-proof fences or stackyards).

Livestock Producers

Livestock producers and grazing allotment permittees operating in the vicinity of the Jackson Bison Herd were contacted by letter in early November 2007. The WGFD made producers aware of the writing of this Plan, and instructed them on how to provide input. Producers were also able to make comments along with the general public at the public meeting, and through the public comment period.

ADDITIONAL ACTIONS

Best Management Practices

In addition to the aforementioned actions and commensurate with their short- and long-term goals, the following best management practices should be considered for bison feeding operations on the NER. Some may be currently employed and should be maintained.

1. Encourage feeders to feed on clean snow.
2. Insist feeders recover any aborted fetus encountered (or contact WGFD so we may do so) and immediately submit to WGFD for testing.
3. Minimize feeding duration to the shortest period possible.
4. Where possible, implement large-scale habitat treatments at strategic locations.
5. Conduct habitat enhancements to improve forage conditions on feedgrounds, when possible and beneficial, such as harrowing and noxious weed control.
6. Encourage the NER to continue feeding bison and elk separately.

Brucellosis Surveillance

The WGFD has been monitoring brucellosis seroprevalence in the Jackson Bison Herd by testing blood samples provided by bison hunters every year since 1999. Given current funding and status of the disease, this practice should continue annually to monitor prevalence of the

disease. Continued surveillance will enable assessments of the efficacy of a potential vaccination program and other strategies in use.

To determine the serostatus of bison, the following five tests are used: 1) Card test, 2) Standard plate agglutination (SPT) test, 3) Complement-fixation (CF) test 4) Rivanol test, and 5) the fluorescent polarization assay (FPA). An animal is considered "seropositive" if 1) either two or more tests react at certain dilution rates, or 2) if the CF test alone shows a reaction at a dilution rate of 2+ 1:20 or higher. The criteria used to determine what is called a positive reactor (positive) for the five serology tests is as follows: 1) Card – positive or negative (no dilution), 2) SPT – 1:100 dilution or greater, 3) CF – 2 + 1:20 dilution or greater, 4) Rivanol – 1:25 dilution or greater, 5) FPA – positive or negative (no dilution). Killing the animal(s) and culturing Brucella from host tissues determines actual infection.

Bison in the Jackson herd have been tested for exposure to brucellosis many times over several years. Research projects at various times of year have tested captured bison for brucellosis. Researchers in GTNP captured bison from 1997-2005 to study reproduction and demography of the Jackson Bison Herd. Captures generally took place in February or March of each year on the NER. During the time of their study, Cain et al. (2005) felt that, on average, brucellosis affected about 70-75% of the adult females in the Jackson Herd.

Hunter-killed bison are harvested typically from September-November, but potentially any time between July and December. The seroprevalence rate of 35 bison collected during herd reductions in 1989 and 1990 was 77%. Four of eleven (36%) seropositive bison collected in 1989 were in turn culture positive (Williams et al. 1993). Hunter-killed bison surveillance has occurred annually since the fall of 1999 (Table 1). Through the 2007 hunting season almost 500 usable samples had been obtained from harvested animals. Sixty-four percent of males (n = 169/263) tested seropositive, and 59% of females (n = 134/226). Knowing the serology of adult cows specifically is most useful because they could potentially transmit the bacteria.

Table 1. Seroprevalence of male and female bison tested through hunter-killed surveillance in the Jackson Bison Herd, 1999-2007.

	Male		**Female**	
Year	**% Seropositive**	**% Culture Positive**	**% Seropositive**	**% Culture Positive**
1999	43 (3/7)	0 (0/8)	33 (1/3)	0 (0/3)
2000	67 (8/12)	0 (0/11)	80 (4/5)	40 (2/5)
2001	63 (15/24)	24 (5/21)	40 (8/20)	23 (4/18)
2002	71 (15/21)	N/A	48 (10/21)	N/A
2003	65 (15/23)	N/A	55 (5/9)	N/A
2004	71 (12/17)	N/A	78 (7/9)	N/A
2005	70 (16/23)	N/A	58 (7/12)	N/A
2006	59 (13/22)	N/A	83 (19/23)	N/A
2007*	63 (72/114)	N/A	59 (73/124)	N/A
Sum	**64 (169/263)**	**12.5 (5/40)**	**59 (134/226)**	**23 (6/26)**

* Only includes adults and yearlings.

Licensed hunters harvested a total of 48 bison from the Jackson bison herd during the fall of 2006. Usable blood samples were collected from 22 of 24 bull bison and 23 of 24 cow bison. Serology results indicated 71% of all bison harvested and tested in 2006 were positive for *B. abortus* antibodies. Male seroprevalence was 59%, and 83% of females were positive (Table 1).

During 2007, 277 hunters participated in the wild bison recreational season. The majority of the harvest occurred on the NER (90% of the cow harvest, 70% of the bull harvest). Licensed hunters harvested 266 bison. Usable blood samples were collected from 114 yearling and adult bull bison, and from 124 yearling and adult cow bison. Serology results indicated 63% and 59% of bulls and cows were positive for *B. abortus* antibodies, respectively (Table 1).

Information and Education

WGFD personnel regularly inform and educate various public factions about wildlife diseases, including brucellosis. Outreach, particularly from the Information & Education (I&E) branch, has included group presentations, regular news releases, interpretive signs at feedgrounds and crucial winter ranges, Game and Fish brucellosis website (http://gf.state.wy.us/wildlife/Brucellosis/), and various brochures and publications. Participation in the Greater Yellowstone Interagency Brucellosis Committee (GYIBC) and the Wyoming Brucellosis Education Team (WBET) has increased I&E brucellosis efforts on statewide and regional levels. The Regional I&E Specialists work closely with the Veterinary Services branch of WGFD and the Wyoming State Veterinary Lab to dispense information. The I&E branch also works to inform bison and elk hunters of brucellosis surveillance in order to increase participation in both statewide and regional efforts.

The importance of quality wildlife habitat, habitat enhancement, disease research, as well as the role of feedgrounds and damage management activities are presented to the public by WGFD personnel at various meetings and conferences. WGFD personnel make numerous private landowner contacts regarding habitat improvement projects, wildlife-friendly management techniques, or ways to prevent commingling of elk and livestock. Additionally, efforts are focused on area school groups and educational exhibits at events such as the Wildlife Heritage Foundation of Wyoming's annual Hunting and Fishing Expo and the annual elk antler auction in Jackson to inform children and their parents of the Brucellosis-Feedground-Habitat (BFH) program and brucellosis management.

These efforts should be continued to inform the public of WGFD's active and cooperative role in brucellosis management. Additionally, as actions outlined in this document are implemented, I&E efforts should focus on why the actions are being pursued and what benefits may be realized. The public should be made aware of any proactive management embarked upon by the WGFD, and their interests in the actions should be heard.

Progress Reporting

Efforts associated with this plan and/or the Wyoming Governor's Brucellosis Coordination Team (Galey et al. 2005) will be summarized and reported on an annual basis.

Research

Sound management of brucellosis in bison and the risk of transmission from bison to cattle necessitate accurate and reliable data to facilitate decisions. Potential research topics that could assist in management decisions are listed below. Items 1-5 were project recommendations included in the BCT report (Galey et al. 2005) relative specifically to bison.

1. Efficacious vaccines for elk and bison (all types, including subunit and DNA vaccines).
2. Cost-benefit and risk analysis of brucellosis eradication in elk and bison.
3. Vaccine delivery systems (including oral, aerosol, and biobullet) development for elk/bison.
4. Efficacy of contraception in elk and wild bison as alternative to test and culling.
5. Efficacy of RB51 in bison.
6. Bison parturition habitat site characteristics and proximity to cattle.
7. Effects of habitat improvement projects on or near bison seasonal ranges on subsequent bison behavior (i.e., distribution, dispersal, length of feeding season, brucellosis seroprevalence).
8. Relationship of brucellosis seroprevalence and feeding duration of bison.
9. Snow-water equivalency measurements in areas of habitat enhancement projects, both past and future, and relationships with bison use and distribution.
10. Alteration of feeding patterns (on the NER) and effect on contact rates of bison with aborted fetuses.
11. Brucellosis social survey examining attitudes and knowledge of brucellosis issues among the Wyoming public, in order to focus information and education efforts.

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JACKSON BISON BMAP
Appendix 1
BISON POPULATION MANAGEMENT

RECENT BISON POPULATION MANAGEMENT

Early in the winter of 1998, 321 animals were counted in the Jackson Bison Herd. In early 2007, 1,059 bison were counted (Figure 3). The exponential increase in bison can be attributed to high productivity, low natural mortality due to supplemental feeding on the NER, and low hunting mortality because bison have seldom been in open hunting areas over the last decade.

With the completion of the BEMP-EIS, GTNP and NER recommended a bison herd objective of 500 animals. The bison population objective of 500 was then formally decided on by the WGFC at their meeting in March of 2008. Based on an annual growth rate of 12%, managers propose harvesting approximately 20% of the population annually until the population objective is reached. With current recruitment the population objective of 500 bison could be reached by 2014.

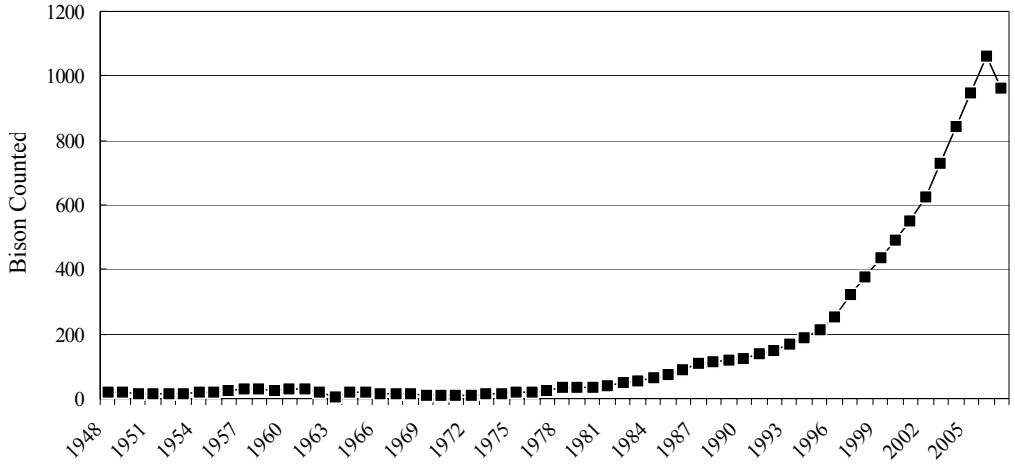

Figure 3. Number of bison counted in the Jackson Bison Herd during winter counts, 1948-2008.

Population Estimate

NER, GTNP, and WGFD personnel conduct winter counts and classifications of the Jackson bison herd each winter (Figure 4). The count is carried out through ground surveys on the NER and concurrent aerial detection flights over the NER, GTNP, and adjacent BTNF lands.

In 2008, the count was conducted in mid-February. A total of 963 bison were counted; 920 of them were on or near feedlines on the NER. In 2007, a total of 974 animals were counted on NER feed lines. Combined with an additional 85 bison counted off feed lines, the 2007 count yielded a total of 1,059 bison. In 2006, a total of 948 bison were counted, with 887 on feed and 61 off feed or on native winter range. With a harvest of 266 animals in 2007, the 2007 post-season population is estimated to be 971 animals.

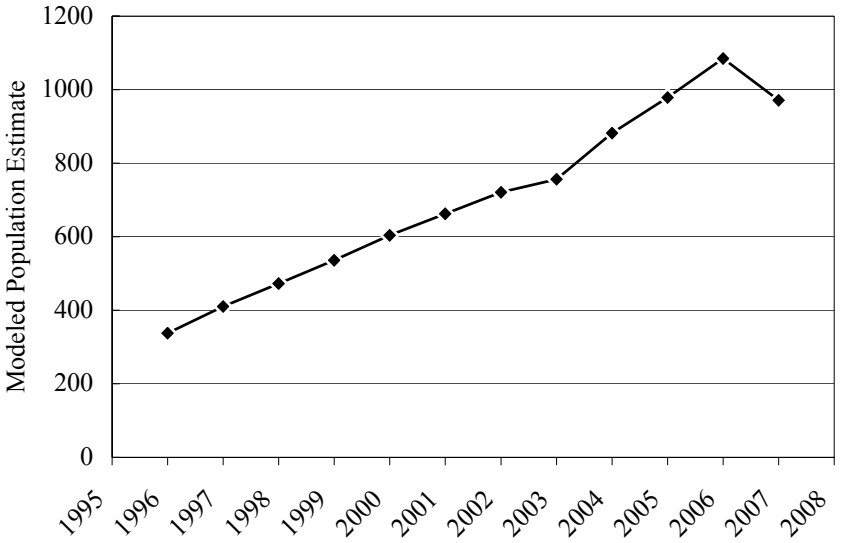

Figure 4. Postseason POPII estimate of Jackson Bison Herd, 1996-2007. (Data from WGFD 2002, WGFD 2007.)

The 2008 count showed the herd to include 260 adult bulls, 84 yearling bulls, 406 cows, and 212 calves. Herd ratios were 85 bulls per 100 cows and 52 calves per 100 cows (Figure 5). The 2007 count showed the herd composition to include 302 adult bulls, 114 yearling bulls, 378 adult cows, 69 yearling cows, and 196 calves. Herd ratios were 93 bulls per 100 cows and 44 calves per 100 cows.

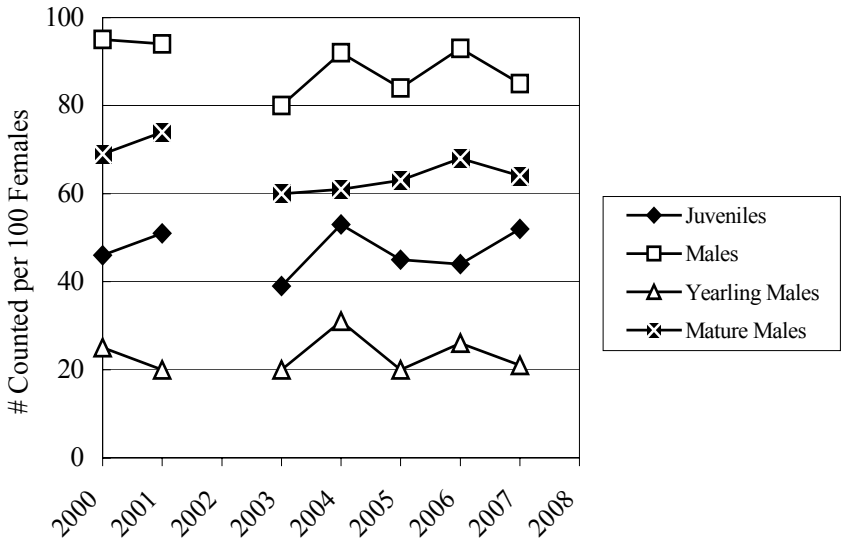

Figure 5. Ratio of calves, bulls, and yearling bulls per 100 cows counted during annual post-hunt trend counts in the Jackson Bison Herd, 2000-2007.

Population Management and Hunting Seasons

Natural mortality in this bison herd is very low. Between 1995-2005, natural mortality ranged from 0.4 – 7.3% of the population. The annual growth rate of the herd more than compensates for the low natural mortality and low number of animals historically harvested by hunters.

Because of animal distribution and prohibition of hunting on the NER, there has been limited opportunity to harvest animals from this population. Hunter numbers have been incrementally increased over the past several years to address increase in bison. Because of the small areas where bison have been available for harvest, hunter crowding has been a concern. Occasionally, bison move off the valley floor onto BTNF lands at a few locations (Figure 2). Now, with the NER open for bison hunting, bison hunting season structure will be designed to accommodate many more hunters.

Type 1 (any male) and Type 2 (any female/calf) licenses are distributed for a *typical* season of September 1 – November 30. The Jackson Regional Office notifies successful applicants by mail in July-August. Orientation materials are sent along with the notification cover letter. Actual licenses are not mailed. Instead, hunters must come to the Jackson Regional Office to pick up their license, at which time they receive the remainder of their packets. Hunters are required to return a harvest information card to WGFD within 72 hours of harvesting their animal. In the last few years, these packets have also consisted of a biological sample kit (blood for brucellosis testing, teeth for aging, and tissues for DNA analysis).

While the hunting season *typically* runs from September through November, some harvest may occur through the use of recreational hunts any time between July 1 and January 31 if bison move to private land and cause damage or become a public safety concern (WGFD 2005).

While elk hunting on the NER is jointly managed by the USFWS and WGFD, through the 1974 cooperative agreement between the two entities (USFWS and WGFD 1974), there is no similar agreement for bison hunting, and bison management is not included in the 1974 agreement. The agreement was drafted so that the USFWS and WGFD would cooperate on aspects of management where there was mutual concern, i.e., elk hunting regulations, elk feeding, herd numbers, habitat conditions, research, etc. At the time that agreement was first created, bison numbers were not an issue, and bison had not yet wintered on the NER. The Cooperative Agreement between the WGFD and the NER is in the process of being updated. With completion of the BEMP- EIS (USFWS and NPS 2007) a bison hunt was established on the NER. During the fall of 2007 approximately 370 bison hunters were contacted by the State of Wyoming to participate in a hunt in the Jackson Bison Herd. Upon purchasing a license from the WGFD, hunters were issued a permit to access the NER.

Harvest & Hunter Success

In 2007 the NER was opened to bison hunters for the first time since 1991. As expected, most of the harvest took place on the NER. During the 2007 season, over 80% of all harvest took place on the NER. Animals harvested in September and October were primarily on BTNF lands. November and December harvest was overwhelmingly on the Refuge. In 2007, 277 hunters harvested 114 adult bull bison, 11 yearling bull bison, 130 female bison, and 11 calf bison. Hunters reported 99% success on bulls and 94% success on cows. Overall, hunters experienced a 96% success rate and spent 3.1 days/animal harvested in the field.

During the 2006 bison season, 52 hunters harvested 48 bison, for a success rate of 92%. Twenty-three of the harvested animals were bulls, 25 were females (Figure 6). Hunters averaged 5 days/animal harvested.

During the 2005 bison season, 49 hunters harvested 24 bull bison and 12 female bison (Figure 6). These hunters reported 100% success on bulls, and 50% success on cows. The 2001-2005 harvests averaged 39 bison harvested and 5.6 days/animal harvested. The average hunter success during this time was 75%.

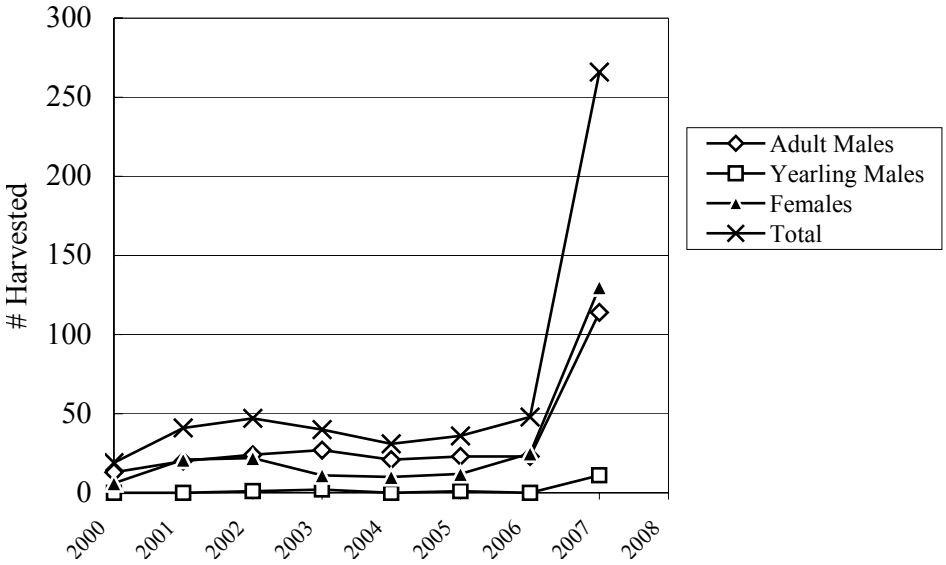

Figure 6. Number of bison harvested, by sex and age class, within the Jackson EHU, hunting seasons 2000-2007.

Feeding on the National Elk Refuge

Feeding elk began on what is currently the NER in 1909 with the State of Wyoming appropriating $5,000 to fund the entire operation. Congress appropriated $20,000 for hay for elk in 1911 (Sheldon 1927). Congress appropriated $50,000 in 1912 and 1913 to purchase 1,760 acres of land immediately north of Jackson. Along with 1,000 acres of public land adjacent, this was the official beginning of what is now the NER. In 1925, an additional 1,760 acres owned by the Izaak Walton League was deeded to the Refuge. By 1927 the total area of the Refuge had grown to slightly over 4,500 acres.

Today, the NER totals about 25,000 acres. A 1974 Cooperative Agreement between the WGFD and NER calls for a maximum of 7,500 elk on feed in any given winter on the Refuge. That agreement is in the process of being updated, taking into account strategies for management and animal numbers outlined in the BEMP-EIS (USFWS and NPS 2007).

Bison have been receiving supplemental feed on the NER since 1980. Since 1984, NER staff has attempted to feed most of the bison at the far north end of the Refuge to minimize their interference with elk feeding operations. In 2007, an average of 832 bison were fed daily (Figure 7). Bison were fed a total of 541 tons, or an average of 19.1 lbs/bison/day. In contrast, elk were fed an average of 8.5 lbs/animal/day. Elk feeding began in 2007 on January 13 and continued through March 21, a total of 68 days. Bison were fed on separate feedlines for a total of 64 days (E. Cole, NER, unpublished data).

Since 1995, an average of about 70% of the Jackson Bison Herd has been receiving supplemental feed on the NER (E. Cole, NER, unpublished data). The highest proportion fed was in the winter of 2005-06, when 81% of the estimated population of 1,085 was on feed. The lowest proportion was in the winter of 2004-05, when slightly less than 50% of the population of 979 was estimated to be on feed. Complete data have not yet been compiled from feeding in 2008.

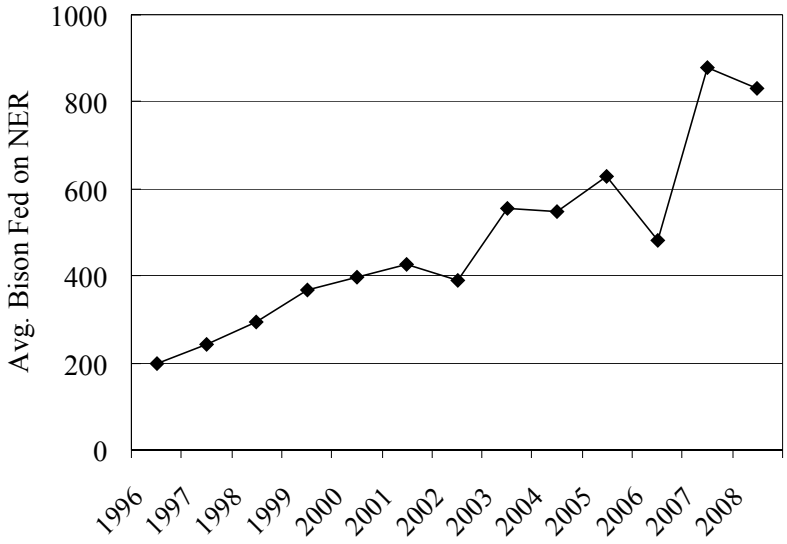

Figure 7. Average number of bison on supplemental feed on the National Elk Refuge. From the winter of 1994-95, through 2007-08.

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JACKSON BISON BMAP
Appendix 2
HABITAT MANAGEMENT

Wildlife habitats in western Wyoming have been modified through fire suppression, urban expansion, oil and gas development, and other anthropogenic practices during the past century (WGFD 2001). Historically, disturbances (primarily wildfire) maintained health and diversity of vegetation communities. Habitat enhancement projects can be employed to mimic natural disturbances, create a mosaic of multi-aged plant communities, and restore habitat to a more properly functioning condition across the landscape. WGFD personnel cooperate with other agencies to implement habitat enhancement projects that restore or create vegetative diversity, increase forage (herbaceous and browse) production, and improve range conditions for myriad species. These projects involve identification of treatment areas, approval of land management agencies and/or livestock permittees, acquisition of funding, habitat inventory, implementation, and pre- and post-treatment monitoring.

Loss of elk and bison habitat, especially winter range, is a major factor in the brucellosis problem, especially for elk. Habitat enhancements have the potential to expand bison distribution and decrease group size when compared to supplemental feeding conditions. Wild and prescribed fires have resulted in significant temporal and spatial distribution shifts. Increased localized forage production has lead to major shifts in bison movements on GTNP and the NER in the last couple of decades. Thus, future habitat enhancements should be designed with animal re-distributions in mind. For example, treatments meant to increase forage production in and around established bison range should be carried out in areas where bison will not be drawn into commingling situations with cattle. Alternatively, habitat could be manipulated to draw bison away from areas occupied by cattle. And, habitat treatments can be used to attract bison for harvest strategy purposes.

As with any wild or domestic ungulate (e.g., elk/moose overuse of willows/aspen, mule deer overuse of various mountain shrubs, cattle overuse of riparian areas), bison themselves can be detrimental to their own habitat. Bison overuse of riparian and sage/grassland habitat in GTNP is readily visible. Increased bison use during summer on the NER also is having a negative impact on the amount of forage that will be available to elk and bison over the winter. Consequently, the NER spent a considerable amount of time hazing bison off the Refuge this summer (2007).

Jackson Interagency Habitat Initiative

The Jackson Interagency Habitat Initiative was formed in the fall of 2001 by several wildlife biologists from the BTNF, NER, WGFD, and GTNP. These resource professionals were concerned about the loss of habitat effectiveness on native ungulate winter and transitional ranges within the Upper Snake River Basin and the challenges the agencies faced in implementing on-the-ground habitat enhancement projects to address current management issues in a coordinated manner. The JIHI group reports its progress and takes recommendations at the annual Advisory Group meeting of the Jackson Cooperative Elk Studies Group.

Because of the large numbers of elk, the large winter-feeding programs, and existing and potential disease issues, JIHI has placed considerable emphasis on enhancement of winter and transitional ranges for elk. Habitat enhancements spread throughout watersheds of the USRB should encourage a wide distribution of both elk and bison and other ungulates in winter, reducing

disease risks. Within occupied habitats, such enhancements will attract bison, and harvest strategies will be adjusted accordingly to reach and maintain the population objective as well as help mitigate over utilization of the treatment sites.

Proposed Habitat Enhancements

Habitat management on the NER and GTNP have already been outlined in the BEMP-EIS (USFWS and NPS 2007). On the Refuge, the EIS states that Alternative 4 Management will decrease the amount of native grassland over time, but because of reduced numbers of elk and bison, the condition of grasslands, and habitat in general will be in better condition. The EIS goes on to state that prescribed fire and wildland-use type fires in native grasslands and shrublands will help sustain those habitats. Forage production on cultivated fields should increase slightly (more palatable and higher quality forage should be produced) through adding to the sprinkler irrigation system and modifications to the flood irrigation system.

In GTNP, the EIS states that Alternative 4 Management will result in fewer areas of bare ground in wet meadow habitats and fewer invasions by non-native plant species because fewer large ungulates would be summering on the Park. Approximately 4,500 acres of agricultural lands would be restored to native plant communities, thus native grasslands and shrublands would be added to the landscape over time. Lower numbers of elk and bison should contribute to a minor increase in species diversity in those plant communities, as well as less bare ground caused by intensive grazing. Periodic prescribed fire would be necessary to maintain herbaceous production, otherwise areas will tend towards sagebrush. As native grasses are restored to the Kelly hayfields, Mormon Row, and Hunter-Talbot areas, these restored agricultural lands could provide relief to ranges on the NER in both spring and fall.

Regarding habitat enhancements on BTNF lands, the JIHI group has been spearheading the Lower Gros Ventre habitat enhancements, which include 17,000 acres of burn units between Ditch Creek and Slate Creek. Implementation began in 2007, and will cover several years. Based on past and current bison use of this area, and ongoing population reductions, the WGFD does not expect bison to drastically expand into the area. Increased use of the Gros Ventre River drainage would be monitored closely, and bison deemed a threat to livestock would continue to be removed through non-lethal or lethal means, as per Chapter 41 regulations.

Prescribed Fires

Prescribed fire has been utilized since the early 1970s to enhance forage and browse conditions. Most habitat enhancement projects affecting the Jackson Bison Herd have occurred on GTNP and NER lands, designed to set back succession in sagebrush/grass communities (Figure 8).

Interagency prescribed fires in the late 1990s on GTNP and BTNF lands in the lower Spread Creek area effectively altered bison distribution. About 8,250 acres of mostly sagebrush and some mixed aspen/conifer were treated with a mosaic burn pattern between 1996-98. Bison responded by expanding their use of the treated area; increased use that cannot be attributed solely to an increasing population. Bull bison were attracted to the burns that occurred on the BTNF adjacent to GTNP as well and hunters have been very successful in harvesting bulls in this area. The number of bison wintering in the area also increased. Wolff Ridge, in the same general lower Spread Creek area, was prescribe burned in 2002. Bison responded similarly to that 1,570 acre burn.

In 2003 the Walton Ranch, with economic incentive, agreed to remove livestock grazing from the Blackrock/Spread Creek Allotment (Figure 10, Appendix 3). Of the 87,500 acres

within the allotment, 75,000 acres were placed in closure status. The remaining 12,500 acres was temporarily placed in vacancy status, pending a suitability assessment to be conducted during the ongoing Forest Plan revision. Grazing had actually not occurred on the allotment in any of the previous four years because of wildlife/livestock conflicts. Commingling of both bison and elk with livestock would be possible if livestock grazed there. Because there is no livestock grazing in the area, habitat improvements will not draw bison into commingling situations. In fact, post closure of the allotment, the JIHI group proposed an interagency prescribed burn on BTNF and GTNP lands. The BTNF burn (Diamond L [1,145 acres]) was completed in the fall of 2005. The GTNP part of the project (Eynon Ridge , 828 acres) was completed in the fall of 2006. The primary objectives were to reduce conifer encroachment and enhance aspen regeneration on winter and transitional ranges for elk. Bison have been attracted to both projects, with hunter-harvest enhanced on the BTNF portions.

Wildfires

Wildfires also have played a major role in seasonal bison distributions. Wildfires have spread across several thousand acres within Jackson Bison seasonal ranges since 1950 (Figure 9). Between 1946 and 1998, at least 22 wildfires occurred on the NER also, but only totaled about 345 acres (Smith et al. 2004).

The 1994 Row fire north of Blacktail Butte in GTNP substantially altered bison distribution for several years. The effect of that wildfire was increased quality and quantity of herbaceous species and less sagebrush. Increased forage production lead to an increase in bison use of those areas, confirmed by radio-collar data from those time periods (Cain et al. 2001, 2004, 2005).

The same thing was seen in late 2003 with the Blacktail wildfire (~2,600 acres). That lighting-started fire burned sagebrush-grassland areas south of Blacktail Butte. The fire burned very hot, consuming most vegetation in the area. Since 2004, because of the increased grass production, bison have used the area extensively, especially from mid-summer through fall and early winter (Cain et al. 2004).

Another example of how fire can influence bison distribution was seen in late summer of 2006. A small wildfire burned on GTNP land, just above the Gros Ventre River near the boundary with the BTNF. There has been some bison use of that hillside this fall (2007).

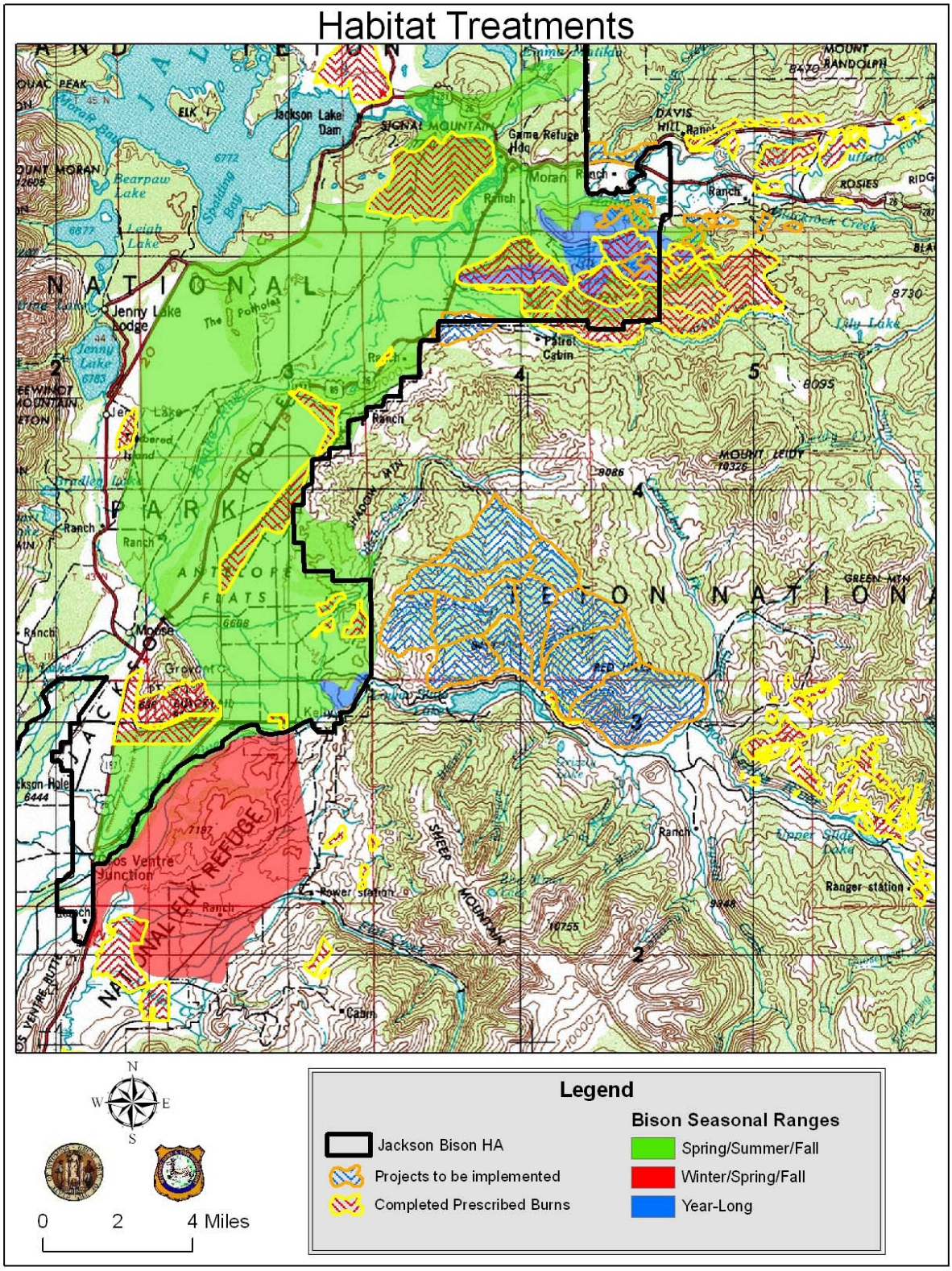

Figure 8. Locations of implemented and proposed habitat enhancement projects within Jackson Bison seasonal ranges.

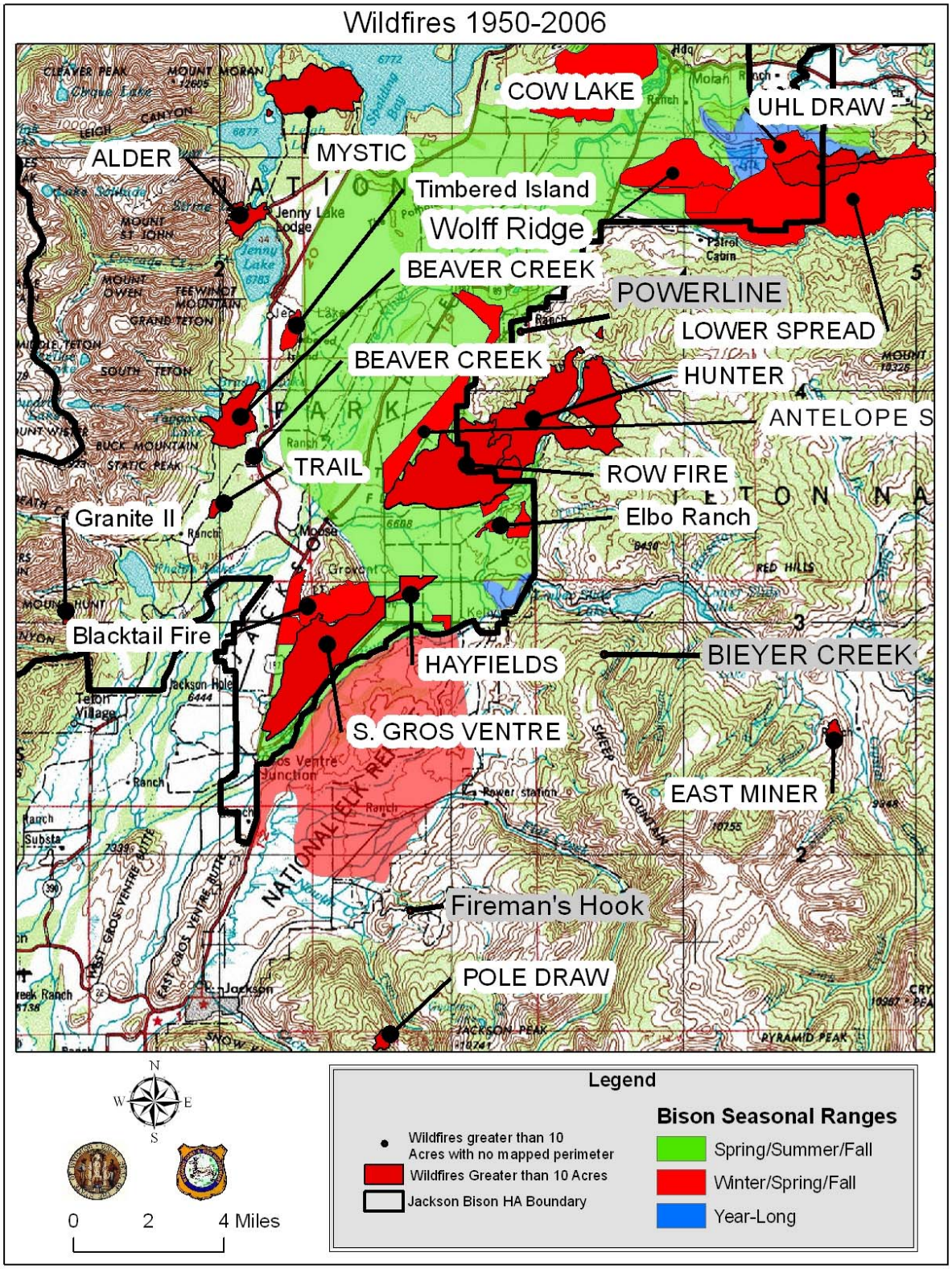

Figure 9. Wildfires in the vicinity of the Jackson Bison Herd Area, 1950-2006.

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JACKSON BISON BMAP
Appendix 3
PREVENTION OF BISON/CATTLE COMMINGLING

Management actions should maintain spatial and temporal separation of bison and cattle during the brucellosis transmission period of January to May. In addition, livestock use of bison ranges should be prevented until after June 15, an allowance for the time that *Brucella* could persist at bison parturition or abortion sites.

Bison Overlap with Public Grazing Allotments

Timing of cattle grazing on BTNF and GTNP grazing allotments can and should be manipulated to assure temporal and spatial separation of bison and cattle until after most bison have calved. Because bison do not occupy much area outside of GNTP and the NER, potential for overlap with public grazing allotments is limited. There are no occupied public grazing allotments where bison typically occur on BTNF lands. The Ditch Creek allotment, on BTNF adjacent to GTNP, is in vacant status – it could be stocked with a District Ranger's decision (Figure 10). There are no cattle grazing allotments on BTNF land adjacent to the Refuge. If bison maintain their current seasonal ranges, no additional areas of spatial or temporal overlap with cattle will take place.

There are public grazing allotments in GNTP (Figure 10). The NPS has developed an elaborate system of grazing management to ensure spatial and temporal separation of bison and cattle. Their system generally divides cattle's use of pastures in the Antelope Flats and Elk Ranch areas based on anticipated bison distributions, emphasizing spatial separation when bison are calving (K. McCloskey, GTNP, personal communication). GTNP also requires cattle to be vaccinated. The requirement for vaccination is included in the individual Special Use Permit issued to each producer on an annual basis.

There are just three different cattle producers with grazing allotments in GTNP. Teton Valley Ranch has cattle year-round on private and GTNP land near Kelly. WGFD delivered fencing materials to the ranch so they could elk- (and bison-) proof a feeding pen they use when elk and bison are nearby. This strategy serves to both 1) avoid giving food rewards to elk and bison, and 2) physically prevents commingling. In recent years much of the bison herd has spent late summer and fall around the Antelope Flats area of GTNP and the town of Kelly.

The Pinto Ranch did not run cattle on the Park last year. They are currently running a yearling steer operation. Their grazing allotment lately has been Elk Ranch. They used Pacific Creek prior to Elk Ranch; the use was moved to Elk Ranch for resource benefit based on current wildlife species distributions. Pinto Ranch in the past typically trailed cattle from their home ranch in the Buffalo Valley to the Pacific Creek allotments on GTNP and BTNF. The Pacific Creek allotment has not been used in the past several years, and that allotment has very low bison use regardless (Figure 10).

Jackson Hole Hereford Ranch took non-use on its Park allotments in 2005, 2006, and 2007. If the Hereford Ranch continues to run cattle in the Park, it would be in the N. Gros Ventre pasture, adjacent to Mormon Row, and on the Elk Ranch (Figure 10), with trailing possible between these two locations.

Another area of concern is cattle grazing on the state land's section at the boundary of GTNP and the BTNF, to the north of Kelly Warm Springs. The grazing permit allows for 343 AUMs. There are no restrictions on when cattle can be run there, but turn-on dates tend to be

conservatively late to avoid overlap with bison. Both bull and cow bison could occupy the area (Figure 10).

WGFD will work with cattle producers and other agencies (e.g., NRCS, BTNF, GTNP) in the Jackson area to implement any changes to their operations that decrease the risk of disease transmission from wildlife. In addition, WGFD and WLSB have already outlined regulations for removing bison that are a threat to cattle (*see* Coordination with WLSB, page 16).

Stackyards & Fencing

Since 1992, elk- and bison-proof fencing materials for 177 haystacks (as of August 2006) have been provided by WGFD personnel to cattle producers in Lincoln, Sublette, and Teton counties in western Wyoming. Since 2000, WGFD personnel have distributed materials for at least five permanent stackyards in the north Jackson area. Currently, all known stackyards in the area are fenced that are associated with test-eligible cattle with the potential for commingling.

In addition to fencing off stackyards, livestock producers have reduced the attractiveness of their feeding areas by fencing them. Fencing winter cattle feedlines prevents bison from commingling with cattle. New fencing projects would require favorable decisions by the landowner. Where fencing stackyards is considered beneficial at reducing damage/ commingling, WGFD provides fencing materials to landowners. WGFD will encourage cattle producers in the Jackson EHU to fence areas where hay is stored (stackyards) for winter-feeding operations and continue delivery of materials for stackyard construction.

Hazing/Hunting

The WGFD and the WLSB cooperate on dealing with bison that leave the established Herd Unit and/or pose a threat to livestock. Chapter 41 of the WGFC Regulations regulates the removal of privately-owned bison, and the removal of wild bison. Section 8 of Chapter 41 outlines the removal of wild bison within the Absaroka and Jackson areas through hunting seasons. However, if wild bison pose a health threat to livestock, as determined by the WLSB, the WLSB may order WGFD to remove the wild bison immediately. Chapter 41 does not specify a time of year (period of exposure) when this applies; only that a health threat to livestock is determined by the WLSB or its designee. Additionally, WGFD may remove a wild bison immediately if it poses an immediate threat to public safety.

In some instances, bison are hazed from cattle feeding sites. Particular problem locations have been ranches in Buffalo Valley and around Kelly, and the area around and including the Jackson Hole Golf & Tennis subdivision, west of Gros Ventre Junction. These animals are removed from areas of conflict via snowmobiles or other means to winter range areas away from cattle. In other cases, when hazing fails to achieve desired results, licensed recreational hunters have been utilized to remove problem animals.

Since 2002, WGFD personnel have lethally removed at least eight bison (seven bulls, one cow) from the Jackson Bison Herd. Two were removed from residential areas because of human safety concerns, the remaining animals were removed because of risks to cattle producers. WGFD personnel took one cow bison on private land in Spring Gulch in February 2003 after the bison gored a domestic beef calf. In late 2002/early 2003, the WGFD lethally removed a bull bison from the Upper Green River area because of disease concerns. The WGFD removed a second bull bison in January 2003 after it was deemed a safety risk to Kelly area residents. Recreational hunters have also been utilized to remove bison from potential commingling situations with domestic cattle.

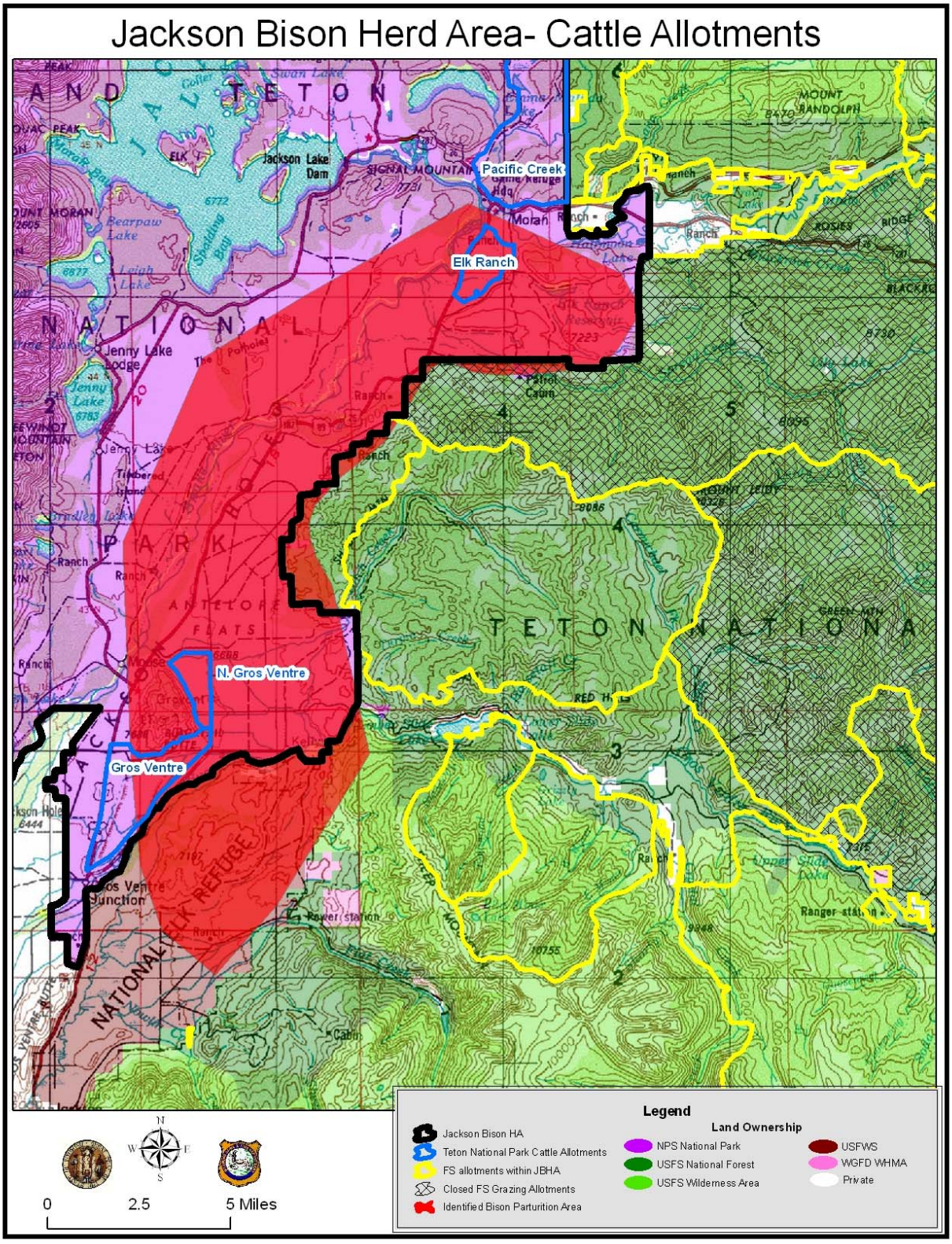

Figure 10. Cattle grazing allotments in Grand Teton National Park, Bridger-Teton National Forest, and areas of overlap with bison parturition range.

JACKSON BISON BMAP
Appendix 4
VACCINATION OF BISON WITH STRAIN RB51

Introduction

Vaccination is considered an important tool for reducing the risk of intra- and inter-specific transmission of brucellosis. *Brucella abortus* strain 19 (S19) and *B. abortus* strain RB51 (RB51) were developed to prevent brucellosis in cattle and have been used in bison and elk. Efficacy of immunizing agents for preventing or minimizing the effects of exposure to virulent strains of *B. abortus* is measured by the percentage protection again both abortion and infections. Although S19 and RB51 do not protect completely against infection or abortion in cattle or bison and elk (Cheville et al. 1998, WGFD unpublished data), they do offer some protection.

The WGFD previously proposed bison vaccination programs to the NER in the late 1980s and early 1990s. The WGFD planned to vaccinate all yearling and older females and all calves in winter on the NER with S19. During subsequent winters only calves and yearling females would have been vaccinated. None of the proposals were accepted (WGFD 1991). The main justification for opposing vaccination at the time was that in clinical trials S19 induced abortions in a small percentage of pregnant female bison (WGFD 1991, Davis 1993). The WGFD now proposes to eventually vaccinate bison with strain RB51. Research has demonstrated that RB51 is both safe (e.g., Roffe et al. 1999, Elzer et al. 1998, Olsen et al. 1998, Olsen et al. 2002) and effective for use in bison (Olsen et al. 2002, Olsen et al. 2003, Olsen et al. 2004).

The preferred alternative of the Interagency Bison Plan of 1997 identified several mechanisms for minimizing transmission from bison to livestock, including using a safe and effective brucellosis vaccine on bison; the Plan was not implemented. In the intervening years while the BEMP-EIS (USFWS and NPS 2007) was being drafted the use of vaccine on Jackson bison has not been pursued. The ROD for the BEMP-EIS states that WGFD will be permitted to vaccinate bison for brucellosis on the NER with a safe and efficacious vaccine as long as it is logistically feasible.

Proposed Action

The WGFD proposes to vaccinate all yearling and older females and all calves on the NER with RB51. RB51 is a commercially available product (Colorado Serum Co., Denver, Colorado). The first year of the program is indefinite at this point. The WGFD would like to implement the program as soon as time, technology, resources, and coordination permit. However, full-scale vaccination of all calves, female yearlings, and adult cows is not feasible immediately with existing technologies and resources.

The WGFD will continue to work on developing a plan for bison vaccination that would be suitable for implementation on the NER. Biobullet technology (*used by the WGFD to vaccinate elk with S19 on the NER since 2003*) has not yet been developed that would effectively and consistently deliver an appropriate dose of RB51 to bison.

One approach with existing technology would be use of darts tipped with biodegradable barbs. Darts containing 1 mL of live *Brucella* strain RB51 containing $1x10^{10}$ colony-forming units (CFU) would be administered remotely via dart gun. The same dosage would be used among juveniles, yearlings, and adults. To ensure the best delivery of vaccine, darts would be

tipped with biodegradable barbs so they would not easily fall to the ground after being shot into individual bison. Thus, we would expect the darts to fall to the ground after 15-30 minutes.

Vaccinating free-ranging bison this way has not yet been attempted, thus it not known if using darts to vaccinate several hundred bison on the Refuge would cause an unacceptable safety risk to wildlife, hunters, and WGFD and NER personnel. Vaccinating a small number of bison on a trial basis would help to determine the feasibility of more complete coverage in subsequent years. We still would need to determine 1) how long it takes for the darts to fall to the ground, and 2) the feasibility of retrieving those darts after they've fallen.

The Jackson herd remains sufficiently confined in distribution such that an effective vaccination program could be undertaken (Smith 2005). Remote delivery would take place during winter when most of the herd utilizes feedlines on the NER. Shooters in snowcats would deliver vaccine to bison on feedlines, similar to ongoing elk vaccination methods.

We will vaccinate with strain RB51 because it is currently the best available vaccine for use in bison. As time and technology progress, it is conceivable that other, more effective vaccines could be developed and employed. DNA vaccines are among the most promising, and several different projects are ongoing (Bienen and Tabor 2006). DNA vaccine technology is developing rapidly but will not be available in the short-term (Roffe and Olsen 2002, USAHA 2006). Any bison vaccination program WGFD implements would be adaptive in using the best available delivery method with the best available vaccine.

Justification

Bison herds can maintain chronic infections of brucellosis in the absence of winter feeding or other forms of artificial crowding (e.g., YNP bison vs. elk), suggesting that bison are a more natural host for *B. abortus*. Their gregarious nature, particularly during parturition, provides ample opportunity for exposure to infected fetuses and live births (Cheville et al. 1998). Thus, the elimination or reduction of feeding on the NER is highly unlikely to eliminate brucellosis in bison, although there may be some decline in the level of infection. The likelihood of Jackson bison to remain chronically infected presents two problems: 1) bison would continue to be a potential source for transmission to cattle, and 2) bison would continue to be a potential source for transmission to elk.

RB51 has been shown to diminish brucellosis infection sufficiently to justify its use (*see* Effectiveness, *below*). Uncertainty about the safety and effectiveness of vaccinating bison has been reduced through numerous studies. Vaccination should decrease the risk of transmitting *B. abortus* from bison to domestic cattle by decreasing the number of bison aborting, and over time, reduce seroprevalence of brucellosis in the bison herd. In addition, RB51 vaccination will not interfere with serological identification of *Brucella*-infected individuals (Olsen et al. 1997, 1998).

Safety of RB51

Safety of the vaccine is determined according to criteria adopted by the GYIBC (1998). A safe vaccine is one in which the bacteria incurs no genetic mutations or reversions and that causes not pathological effects, death, or disability in non-target animals exposed to the vaccine or vaccinated animals. A safe vaccine also cannot negatively affect the short-term survivability of representative ungulates, rodents, carnivores, or avian species under experimental conditions.

To be defined as safe for calfhood vaccination, a vaccine would not have any effects that would increase predation or decrease survival. Effects that are short-term and minimal with no

long-term effects may be acceptable. The vaccine would not be shed from the animal prior to parturition. The vaccine strain should not significantly reduce the survival or reproductive potential of the individual. Safety is essentially the same for adult vaccination, with the inclusion that the vaccine will not induce an abortion rate that in and of itself would reduce the population of the target species. Overall, RB51 appears to meet the criteria for a safe vaccine (*see also* Clarke et al. 2005, Montana Department of Livestock 2004, Wallen and Gray 2003).

Some experiments have been conducted to evaluate the safety of RB51 vaccine for use in bison calves. The vaccine is clinically safe when administered to calves from 3-7 months of age using doses up to $6x10^{10}$ CFU (Roffe et al. 1999, Elzer et al. 1998, Olsen et al. 1998, Olsen et al. 2002). Bison vaccinated at 3 months of age took longer to clear the vaccine than those vaccinated at 7 or 8 months (Elzer et al. 1998, Olsen et al. 1998). None of the studies reported any significant pathological effects or shedding of bacteria.

Some studies have found adulthood vaccination of bison with RB51 to be safe, but more research may be needed to define appropriate dosages. Elzer et al. (1998) noted that bison gave birth to healthy calves when vaccinated in the first trimester of pregnancy. Palmer et al. (1996), administering $1x10^{9}$ CFU subcutaneously between 3 and 8 months gestation, found that RB51 caused placentitis, and induced abortion in 2 of 8 pregnant bison. An additional cow delivered a full-term live birth 12 to 13 days post vaccination, but the calf died within 2 days. Those researchers felt that lower doses may be necessary for bison than for domestic cattle, and that caution should always be exercised when vaccinating pregnant bison. Roffe and Olsen (2002) also noted some concern over the safety of RB51 when used on pregnant bison. Olsen and Holland (2003) did not observe any abortions or other adverse effects when they booster vaccinated 48 pregnant bison that were originally vaccinated as yearlings.

The safety of RB51 in non-target species has also been studied extensively. Results indicate secondary exposure to RB51 (i.e., bison being scavenged upon) had no adverse effects, and the use of RB51 in free-ranging wildlife in the Greater Yellowstone Area (GYA) would not be expected to harmfully affect wildlife species encountering vaccinated bison (Roffe and Olsen 2002, Cook and Rhyan 2002). Kreeger et al. (2002) reported that a single oral dose of RB51 was safe in bighorn sheep (*Ovis canadensis*), mule deer (*Odocoileus hemionus*), pronghorn (*Antilocapra americana*), moose (*Alces alces shirasi*), and coyotes (*Canis latrans*). Olsen et al. (2004) studied RB51 safety on black bears (*Ursus americanus*); no adverse clinical, histological, or reproductive effects were found. Januszewski et al. (2001) reported no morbidity or mortality in ground squirrels (*Spermophilus richardsonii*), deer mice (*Peromyscus maniculatus*), prairie voles (*Microtus ochrogaster*), or ravens (*Corvus corax*) orally inoculated with RB51.

Effectiveness of RB51

Protection afforded by *Brucella* vaccines can be categorized as protection against abortion and/or infection (Roffe and Olsen 2002). Protection against either may not be identical, as not all animals that become infected will abort. From a perspective of population-level transmission, protection against abortion is more important (Roffe and Olsen 2002). In clinical trials, protection is usually defined as a statistically significant decline either in abortion, fetal/calf colonization, or maternal colonization between vaccinated and control groups (Roffe and Olsen 2002, Elzer et al. 2002).

Controlled experiments have not provided consensus on the effectiveness of RB51 to protect against abortions in bison (Davis and Elzer 1999, Elzer et al. 2002, Roffe and Olsen 2002, Olsen et al. 2003). Peterson's (2003, cited by Smith 2005) review of the RB51 vaccine

trials at Texas A&M concluded that it offers little protection against abortion or infection in bison. Elzer et al. (2002) reported no significant difference in abortion or infection rates among non-vaccinated controls and two groups of vaccinates ($1x10^{10}$ CFU). One group received a single calfhood dose, the other group was vaccinated at 7, 12, and 15 months of age.

Some evidence of efficacy has been demonstrated (Olsen et al. 2002, Olsen et al. 2003, Olsen et al. 2004). Olsen et al. (2003) suggested that calfhood vaccination with RB51 would be beneficial in preventing transmission of brucellosis in bison. Calves were given a single dose of RB51, then challenged with S2308 mid-gestation. The incidence of abortion was greater in the non-vaccinated group (62%) than vaccinated (15%). Calves from vaccinated cows also had reduced prevalence of fetal infection with S2308 (19% vs. 62%). Those trials suggested that calfhood vaccination with RB51 was efficacious in protecting against intramammary, intrauterine, and fetal infection following exposure to a virulent strain of *B. abortus* during pregnancy. The amount of bacteria that was recovered from uteri and mammary glands of vaccinates was less than controls, thus vaccination appeared to reduce the potential transmission of *Brucella* from infected vaccinates to susceptible bison.

Delivery Method

One of the reasons that bison vaccination has been limited in scope is the lack of a suitable remote delivery system. The most feasible option currently available for remote delivery is the ballistic delivery of darts or bio-absorbable projectiles (Aune et al. 2002, U.S. Animal Health Association 2006). An effective and cost-effective remote delivery system would be preferable to hand vaccination for large-scale use in bison. Hand vaccination would require capture and handling facilities built on either GTNP or the NER. Hand vaccination would be time consuming, labor intensive, and stressful to the animals.

The most reliable method for remote delivery currently available, based on survival of the vaccine and firing integrity and accuracy, is a dart. Ballistic delivery would be feasible at distances up to 50m using Pneu-Dart CO^2 rifles (T. Kreeger, WGFD, personal communication). Ballistic delivery of vaccine via dart presents some liability risks that are not associated with biobullets, such as leaving behind darts on the ground that field personnel may not be able to locate after delivery. Darts not found would be a slight hazard (Ashford et al. 2004). However, only NER personnel and WGFD vaccinators would be allowed on the Refuge during this time of year, and all of those people would be trained on how to handle and dispose of the darts.

Olsen et al. (2002) immunized bison calves with RB51 either ballistically (remote) or by hand. Antibody titers of ballistically vaccinated bison did not differ at any time (2 through 24 weeks) from titers of hand vaccinates. But, peripheral blood mononuclear cells from hand vaccinates had greater responses to RB51 than ballistic vaccinates. They suggested ballistic delivery might require a greater dose of RB51 to induce cell-mediated responses in bison that would be comparable to those induced by hand vaccination.

Olsen et al. (2004) compared immune responses of bison vaccinated with either freshly grown RB51, or various dosages of the commercially available vaccine. Antibody responses in all vaccinated bison were greater than in non-vaccinated controls. The source of the vaccine, and the dosage (1.3 to 13.4 x 10^{10} CFU) did not vary the immune response.

Clarke et al. (2005) stated that collaboration between YNP and researchers at Colorado State University resulted in a new method of encapsulating the vaccine for ballistic delivery. Their method of encapsulation resulted in $1x10^9$ CFU of bacteria surviving from an original dose

of $1x10^{11}$ CFU. They also felt their method resulted in a biobullet that would retain the ballistic characteristics similar to the traditional method.

More recently, Olsen et al. (2006) compared three delivery methods of RB51 for bison: parenteral, ballistic delivery with compressed pellets, and ballistic delivery with hydrogels. Traditional methods of lyophilization and compaction have been thought to create high levels of mortality of the live vaccine. Olsen et al. (2006) suggested immune responses to RB51 hydrogel bullets were similar to hand delivery, but that hydrogels may be superior to compressed RB51 biobullets. A supposed disadvantage of the hydrogel-based biobullets used in that study was reduced structural integrity and firing reliability.

The possibilities for technological advances in the arena of remote delivery are very promising (Christie et al. 2005, Clarke et al. 2005). Thus, adaptive management strategies should be used to adjust to uncertainties, and choose the best approach possible.

Simulation Modeling

To be useful, a vaccination program must be devised and carried out at the appropriate scale (Bienen and Tabor 2006). Researchers have attempted to model the dynamics of brucellosis transmission in the GYA, particularly in bison. Most attempts have tried to determine the potential effectiveness of vaccination, test and slaughter, or a combination of the two.

Some reports have suggested that even with a highly effective vaccine, brucellosis would not be eradicated from the Jackson Bison Herd (Peterson et al. 1991a, 1991b). Peterson et al. (1991a) concluded that when 80% of all females were vaccinated, it would not be possible to reduce seroprevalence to 10% in the Jackson herd over a 20-year period. This in part was due to the assumption of a constant rate of infection of the elk; it would not be possible to substantially reduce seroprevalence unless contact were limited between susceptible bison and infected bison and elk. Peterson et al. (1991b) modeled the effects of different vaccination efficacies on the Jackson Bison Herd, when the population was still less than 100 animals. Their simulations indicated that reducing seroprevalence to less than 10% through vaccination of calves would require a vaccine efficacy of 90%.

Results of other modeling exercises have been more optimistic in what effect vaccination could have on reducing the rate of brucellosis transmission and infection. Simulations by Gross et al. (1998) suggested that rates of immunization for bison calves would have to be around 60% for at least two decades to eradicate brucellosis. Lower levels of vaccine effectiveness would reduce brucellosis prevalence, but not eradicate the disease from bison. Gross et al. (1998) simulated a population of 1,500 animals. Gross et al. (2002) modeled the probabilities of exposure to shed bacteria in the YNP system and determined that vaccination in combination with test & slaughter programs would reduce the risk of brucellosis transmission by driving down the seroprevalence rate in YNP's bison population. They also reported from their predictive models that small-scale vaccination would not work, but that vaccine use in bison could eradicate brucellosis within several decades if at least 40-50% of bison were consistently vaccinated.

Strain 19

Research has not shown S19 to be a safe and efficacious vaccine for use in bison. S19 has not been shown to protect bison against abortion or infection (Davis et al. 1991, Davis 1993) sufficiently to justify its use in the field.

Researchers at Texas A&M University extensively studied S19 for use in bison. In an early susceptibility trial, bison were challenged with *B. abortus* strain 2308 (~field strain), and 50% of the test subjects aborted (Davis et al. 1990). Davis et al. (1991) injected 92 pregnant adult bison with the same dose of S19 used for cattle. Abortions began 60d post-immunization and continued for 3 months. Fifty-eight (63%) of the 92 had aborted, another 5 possibly aborted unobserved. Of the 13 fetuses salvaged, 12 were culture positive for S19. Two of the immunized cows that aborted in year 1 of the study also aborted in subsequent years- the infection had become chronic (Davis 1993). The bison were challenged again 13 months post vaccination. Protection against abortion was 67% in the vaccinated group, 0% in the non-vaccinated control group. Persistent antibody titers, vaccine induced abortions, and chronic S19 infections indicated the S19 vaccine dose used in that series of studies was not suitable for pregnant bison.

In a subsequent study, Davis (1993) immunized 60 bison cows with S19 when they were 8 months of age, then challenged them with S2308 during their 2nd trimester of pregnancy. The percentages of bison aborting (75%) and becoming infected (91%) were not significantly different from the non-immunized control group.

Vaccination of Yellowstone Bison

The Interagency Bison Management Plan for Yellowstone and Montana stated that RB51 met the necessary safety criteria for use and demonstrated sufficient efficacy in bison to call for an EIS to evaluate its use throughout YNP (Clarke et al. 2005). Vaccination of bison around YNP's west and north borders is ongoing. Hand vaccination with RB51 began at the Northern IBMP Management Area in early 2004. One hundred thirteen calf and yearling bison were vaccinated. Nine yearling bison were vaccinated at the Western IBMP Management Area in spring of 2005 (Clarke et al. 2005). Widespread vaccination of bison inside the Park via remote delivery is expected to take place after they develop a long-term surveillance plan and complete the associated EIS (Rick Wallen, YNP, personal communication).

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