JACKSON BISON HERD

LONG TERM MANAGEMENT PLAN

AND

ENVIRONMENTAL ASSESSMENT

Grand Teton National Park
National Elk Refuge
in cooperation with
Wyoming Game and Fish Department
Bridger-Teton National Forest

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EXECUTIVE SUMMARY

Free-ranging bison (Bison bison) were reintroduced to Jackson Hole from the Jackson Hole Wildlife Park in Grand Teton National Park in 1969. By March 1996, the herd had grown from 16 animals to approximately 255. A number of unresolved bison management issues, some of which were controversial, led to the development of this Jackson Bison Herd Management Plan and Environmental Assessment by Grand Teton National Park (National Park Service) and the National Elk Refuge (U.S. Fish and Wildlife Service) in cooperation with the Wyoming Game and Fish Department and the Bridger-Teton National Forest (U.S. Forest Service). Since 1987, when a draft environmental assessment and management plan for the Jackson bison herd (JBH) was released but not adopted, the level of monitoring of the herd has increased and several studies of the herd's biology and ecology have been completed. That biological information, the results of two public scoping efforts in 1987 and 1991, and the agencies' concerns and responsibilities were integrated to form the goals and objectives of the draft Jackson Bison Herd Management Plan and Environmental Assessment released in November 1994. Public response to that draft Plan (see Appendix IV) and additional biological information provided the basis for changes that have been incorporated into this final Management Plan and Environmental Assessment.

The plan's overall management goal is to maintain a free-ranging bison herd in Jackson Hole, as free from human intervention as practically possible. The management objectives are:

1. to maintain a self-sustaining population,
2. to minimize the potential for transmission of brucellosis (with which some bison are infected) among bison, elk, and domestic livestock,
3. to reduce the dependency of bison on supplemental feed to the extent practical,
4. to maintain recreational opportunities associated with a free-ranging bison herd, and
5. to minimize the potential for bison-human conflicts and property damage caused by bison.

The framework of this management plan and environmental assessment was developed around four central management issues (Table 1). For each of the issues, four to seven management alternatives were then developed and their environmental consequences evaluated in accordance with the National Environmental Policy Act. The four preferred alternatives to address the management issues call for the following.

1. Maintain a free-ranging herd of 200-250 bison. To address population genetic concerns, the herd must be maintained at or above a minimum of 200 animals. A herd of 250 would provide a protective margin against loss of genetic variability. A herd of 200-250 animals would also allow for effective range management and address disease concerns associated with larger herd sizes. This alternative was modified somewhat from the 1994 Draft preferred herd size alternative because of new information on bison breeding systems and implications for genetic integrity.

2. Control the maximum size of the JBH through a combination of a small public "fair chase" hunt and culling of bison for Native American use. Hunting and herd reductions would take place on the National Elk Refuge and Bridger-Teton National Forest lands. The ages and sexes of animals to be removed would be carefully determined to assure that genetic viability and a 1:1 sex ratio are maintained in the JBH. This alternative is different from the preferred herd reduction alternative in the 1994 Draft Plan, which called for all reductions to be accomplished through public hunting.

3. Attempt to modify the winter distribution of the JBH. To diminish their reliance on the supplemental feed distributed to elk and to decrease the potential for interspecific transmission of brucellosis and other contagious diseases, bison would be encouraged to winter in southern Grand Teton National Park. A combination of resuming irrigation of the Hunter-Talbot fields and providing (on a temporary basis) a limited quantity of highly palatable bait would be used to attempt to modify bison distribution. Baiting would be done for a limited time only, to habituate bison to a new wintering area. A permanent feeding station would not be established within the Park. Natural forage in the Hunter-Talbot area would provide the bulk of the bison's diet. Based on forage production measurements, the Hunter-Talbot and Mormon Row-Kelly Hayfields area in the Park could support about 210 bison in winter. If successful, this alternative would address concerns associated with bison and elk mixing on the NER feedgrounds, as well as maintaining a free-ranging herd.

4. Reduce the risk of brucellosis transmission among bison, elk, and cattle. Efforts would include 1) attempting to separate bison from elk and cattle during periods when the potential for brucellosis transmission is greatest, 2) using an efficacious brucellosis vaccine, when one is developed for bison, to reduce brucellosis prevalence in the JBH, 3) recommending vaccination of all cattle grazed on federal lands in Jackson Hole, and 4) developing risk assessments to identify the probability of disease transmission between wildlife and livestock in time and space, and using these as the basis for developing effective brucellosis management programs.

This plan is intended to guide management of the JBH over the next decade. It will be implemented cooperatively by the four agencies that developed the plan and will be amended in the future, as necessary, as new information, technology, or issues involving the JBH arise. The public will be notified of any proposed amendments to the plan, and any significant amendments will be subject to review under the provisions of the National Environmental Policy Act.

Table 1. Matrix table of alternatives by management issues identified for the Jackson Bison Management Plan. For each management issue, the preferred alternative is highlighted.

SUMMARY OF MANAGEMENT ISSUES AND ALTERNATIVES

Management Issue	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7
Herd Size	No Action The herd would be allowed to self-regulate, possibly reaching a population size of over 1,000 before levelling off	90 - 110 The herd would be maintained at the 1988 Interim Management Plan level	**200-250** **The herd would be maintained at the minimum level necessary to protect heterozygosity, possibly exceeding 200 if a portion of it wintered off of the NER**	350-400 The herd would be allowed to grow to 350-400 bison, providing an effective population size of 100 without induced immigration	N/A	N/A	N/A
Herd Reduction Methods	Sterilization or Contraception Animals would be sterilized or treated with a reversible contraceptive to maintain a given herd level	Agency Reductions Agency personnel would remove bison on the NER and sell or donate carcasses	Public Hunt Reduction Bison would be removed by sport hunters through WGFD on NER or BTNF lands	Trap and Transport to Quarantine Bison would be trapped, tested for disease, and transported to quarantine facility if disease-free or tagged and released if test-positive	Native American Hunt Reduction Native Americans would be allowed to harvest and keep animals from the herd	Trap, Test & Slaughter Bison would be trapped, tested for disease, and killed if test-positive. Carcasses would be sold or donated.	**Public Hunt / Reduction for Native American** **Public "fair-chase" hunt would remove 5-10 bison; remainder would be made available to Native Americans**
Winter Distribution	No Action Bison would continue to winter on the NER and consume supplemental elk feed	Fence At Hunter-Talbot Bison would be herded into a fenced enclosure in GTNP during winter and possibly supplementally fed	Feed At Hunter-Talbot - No Fence Bison would be supplementally fed during winter in GTNP to keep them away from NER feedlines	**Modify Distribution Through Baiting** **Bison would be baited at the Hunter-Talbot to try to modify winter distribution**	Fence Within Enclosure at NER Bison would be herded into a fenced enclosure on the NER during winter and possibly supplementally fed	N/A	N/A
Disease Management	No Action No action to control or eliminate disease from the herd would be taken	Test and Removal Bison would be rounded up, tested for disease, and removed from the population if infected	Vaccinate Bison would be vaccinated against brucellosis with Strain 19	Depopulate The entire population would be removed and then restocked with disease-free bison	**Minimize Contact** **Contact between bison and cattle would be minimized, new vaccine used, and risk assessment done**	N/A	N/A

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PURPOSE AND NEED

This plan has been written to address challenges and necessary management actions associated with the population growth, behavior, distribution, and disease status of the Jackson bison herd (JBH). The plan's proposed actions are designed to address the following concerns:

1. The once fenced (1948 - 1968), then free-ranging and naturally regulated (1969 - 1980) Jackson bison herd has inadvertently become habituated to human-provided food intended for elk in the winter. Because of the artificial food source, the bison herd's distribution has changed and the herd is artificially concentrated during winter.

2. Because neither natural winter mortality nor predators are playing a significant role in controlling the bison population, the population is no longer naturally regulated and its annual rate of increase is high. As bison numbers increase, the potential for associated management problems increases as well. Potential issues include increased risk of disease transmission, competition with elk and other wildlife, property damage, and erosion and overgrazing. In the absence of natural population controls, wildlife management actions designed to control bison numbers will be necessary.

3. The concentration of bison on National Elk Refuge (NER) feedlines during winter creates unnaturally high levels of disease transmission opportunity. Some bison in Jackson Hole are infected with brucellosis. The disease is not a problem for the bison themselves, but transmission of brucellosis from bison to domestic livestock is a possibility. Infection of domestic livestock could have serious economic consequences for the livestock industry in Wyoming.

Issue Summary

Human settlement has usurped the most productive ungulate winter range in Jackson Hole, forcing wildlife into smaller and less optimal areas. Because of its location and lighter snow accumulations than surrounding areas, the National Elk Refuge provides the most attractive wintering grounds for Jackson Hole elk and bison. In order to minimize elk conflicts with humans and to maintain numbers at desired levels, Jackson Hole elk have been intensively managed since the early 1900s. The elk concentrate on the NER in the winter and are provided with supplemental feed. Major predators are mostly absent from the NER, although this is likely to change as gray wolves re-establish populations in the area.

Historically bison wintered on lands that now comprise the NER, as evidenced by the presence of prehistoric bison remains there. In 1975, the small Jackson bison herd (then 18 animals) began wintering on the NER. Bison use of standing forage on this natural winter range is viewed as natural behavior and is not discouraged by managers. In 1980, however, the bison began eating supplemental feed being provided for elk, and they have continued to do so every winter since.

The bison's discovery of supplemental feed led to several consequences. Winter mortality declined and the population's growth rate increased. The formerly free-ranging and relatively naturally regulated population came under human influence to a much greater degree than it had before, migrating to the NER every winter and relying on the supplemental feed. Bison on the elk feedlines disrupted feeding operations and displaced elk. In order to separate bison and elk, managers have provided separate feedlines for bison since 1984. As the population has grown, separating elk and bison on feedlines has become more difficult, and the bison are now fed more than a maintenance ration to reduce displacement of elk from feedlines.

As long as the bison continue eating supplemental feed, their population is expected to continue growing at a high rate. Since becoming free-ranging in 1969, the Jackson bison herd has grown to approximately 250 animals, and it is increasing at about 16% annually. It is estimated that the population would ultimately level off at about 1100 bison if control measures (sterilization, culling, hunting) are not applied. A population of this size could have significant impacts on vegetation, soils, and other wildlife, and would increase the risk of disease transmission from bison to domestic livestock. Increasing conflicts with humans are likely as both bison and human populations continue to grow and bison expand their ranges. Costs of providing supplemental feed for bison will continue to grow as well.

Managers are faced with the choice of continuing to supplementally feed bison or attempting to restore the herd's free-ranging behavior and independence from supplemental feeding. Without some form of active management to change bison behavior, bison will continue seeking out the most readily available winter food source, the supplemental feed on the NER, even if adequate forage is available in other areas to meet their nutritional needs.

Another decision that must be made is whether to allow the population to grow without constraints or to maintain the population at a predetermined level, as is done with other large herbivores. If population control is chosen, the appropriate population size must be determined. Criteria for such a determination include the need to maintain the population's genetic integrity, the availability of habitat and forage to support different population levels, and the ecological role of bison in the ecosystem. Other important considerations are impacts of different population sizes on other wildlife, vegetation, recreational and aesthetic values associated with bison, risk of disease transmission, social and economic impacts, and human safety and property. Appropriate population control methods must be chosen, based on practicality, cost, humaneness, and acceptance by the public.

Concentration of wildlife at artificial food sources increases the opportunity for transmission of infectious and parasitic diseases. Although brucellosis has been known to occur in Jackson Hole bison since 1963 and in elk since 1930, public concern over the possibility of transmission to cattle has intensified in recent years. Severe economic consequences could result if livestock become infected, both for owners of infected herds and, because existence of infected herds could affect Wyoming's brucellosis-free status, for the state as a whole (USDA-APHIS 1992).

While recognizing that comprehensive management of brucellosis in elk, bison, and domestic livestock will be needed to minimize the risk of disease transmission from wildlife to domestic livestock, this plan focuses on a variety of immediate and near-future disease management measures directed specifically at Jackson bison that should reduce that risk. Long-term management of brucellosis in Greater Yellowstone Area (GYA) wildlife, including Jackson bison, will be planned for in an ecosystem-wide environmental impact statement proposed to be cooperatively prepared by members of the Greater Yellowstone Interagency Brucellosis Committee (GYIBC) (GYIBC 1995).

The bison herd now represents a substantive presence in Jackson Hole. Many of the management issues surrounding the herd are controversial, and a wide range of opinions have been expressed by various interest groups about how the herd should be managed. Because of its distribution, the herd falls under the land management jurisdictions of Grand Teton National Park (GTNP), the National Elk Refuge, and the Bridger-Teton National Forest (BTNF), and the wildlife management jurisdictions of GTNP, NER, and the Wyoming Game and Fish Department (WGFD). In addition, the Wyoming Livestock Board has authority to require removal of bison from some public and private lands. These attributes combine to create a wildlife management challenge with no precedent, a challenge that demands an informed, thorough, and cooperative approach among the responsible agencies and that recognizes the public's varied interests.

SCOPING AND PUBLIC INVOLVEMENT PROCESS

During the last 10 years several management plans or plan guidelines have been written for the Jackson bison herd. Since 1987 when the first environmental assessment was prepared, and through the subsequent adoption of the 1988 interim management plan and preparation of the 1994 draft long-term management plan and environmental assessment, the agencies' primary objective has been to complete a viable, long-term management plan for the herd that represents a workable compromise of the many agency and public interests.

A scoping statement announcing the preparation of a management plan for the JBH and soliciting comments on the plan was released by GTNP on May 16, 1991 (Appendix III). The statement was distributed to local and regional newspapers, conservation groups, government agencies, and private individuals. Management issues identified in the scoping statement were generated by the agencies and were based primarily on past management experience and analyses of public comments received on the 1987 Environmental Assessment (see Appendix II). The comment period was published to run until June 15, 1991, but the agencies accepted all late comments as well. A total of 9 written comments were received addressing all aspects of herd management.

The agencies met on July 12, 1991 to review and analyze the comments received from the scoping statement. Responses to the scoping statement included most of the same issues raised during review of the 1987 Environmental Assessment. All comments were taken into consideration and, based on this input, the following primary goals, objectives, and management issues to be addressed in the plan were developed. Public comments obtained on the 1994 draft of this plan (Appendix IV) further supported these as appropriate components of the analysis.

GOALS, OBJECTIVES, AND MANAGEMENT ISSUES

Overall Management Goal:

To maintain a free-roaming bison herd in Jackson Hole, as free from human intervention as practically possible.

Management Objectives:

1. To maintain a self-sustaining population.
2. To minimize the potential for transmission of brucellosis among bison, elk, and domestic livestock while working toward elimination of the disease.
3. To reduce the dependency of bison on supplemental feed to the extent practical.
4. To maintain recreational opportunities associated with a free-ranging bison herd.
5. To minimize the potential for bison-human conflicts and property damage caused by bison.

Management Issues:

1. Herd Size
2. Herd Reduction Methods
3. Winter Distribution
4. Disease Management

Following the designation of the 4 primary management issues, a range of management alternatives for each issue was developed. In order to allow for the free development of a full range of alternatives for each management issue, current agency policies and regulations were not viewed as absolute barriers (changes in agency policy or regulation necessary to implement any of the alternatives are discussed under ENVIRONMENTAL CONSEQUENCES). A summary of the issues and alternatives covered in this document, including the agencies' preferred alternatives, is presented in Table 1. The range of alternatives under some management issues were revised as a result of the comments received on the 1994 draft. Consequently, those presented here differ somewhat from those presented in the 1994 draft. Detailed descriptions of each of the alternatives by management issue are presented in the MANAGEMENT ISSUES AND ALTERNATIVES section. Analysis of the impacts associated with each of the alternatives is presented in the ENVIRONMENTAL CONSEQUENCES section.

BACKGROUND INFORMATION

Origin and History of Bison in Jackson Hole

The American bison (Bison bison), or buffalo, is native to Jackson Hole (Fryxell 1928, Ferris 1940, Skinner and Kaisen 1947, Haines 1955, Hall and Kelson 1959, Long 1965, Love 1972, Wright et al. 1976, McDonald 1981). Prehistoric bison remains have been found throughout the valley along the Gros Ventre River, the west slope of the Gros Ventre Range, on the National Elk Refuge, and along the Snake River south of Jackson (Fryxell 1928, Ferris 1940, Love 1972). Historically bison likely inhabited the northern areas of Jackson Hole as well, especially in summer. Areas where bison remains have been found represent key ungulate wintering areas, where most bison mortality would be expected to occur, thus accounting for the lack of remains found further north in the valley. The number of bison that once inhabited the valley is unknown. At least one reference exists, however, for an observation of "...a large herd of buffalo in the valley ..." during June of 1833 (Ferris 1940). By the mid-1880s bison had been almost extirpated in Wyoming (Trenholm and Carley 1964) except for a small herd in Yellowstone National Park (Bailey 1930 as cited in Long 1965, Wright 1975). A small group of 8-12 free-ranging bison, whose origin is unknown, persisted in the Red Desert until the mid-1950s (Dr. David Love, pers. comm. 1996).

After the slaughter of 30-60 million bison in North America from 1830-1880, Yellowstone National Park (YNP) had one of only 2 remnant bison herds in the United States, totaling 550 animals. With the exception of 3 Yellowstone bison that wandered south into Jackson Hole in 1945 (Simon, date unknown), bison were absent from Jackson Hole from at least 1840 until 1948 when 20 animals (3 bulls, 12 cows, and 5 calves) from YNP were introduced to the 1500-acre Jackson Hole Wildlife Park near Moran. The Jackson Hole Wildlife Park was a private, non-profit enterprise sponsored by the New York Zoological Society, the Jackson Hole Preserve, Inc., and the Wyoming Game and Fish Commission (Simon, date unknown). It served as an exhibit of important large mammals as well as a biological field station for the Rocky Mountain area. A population of 15-30 bison was maintained in a large enclosure here until 1963 when brucellosis, caused by the bacterium Brucella abortus, was discovered in the herd. Several months later, all 13 adults in the population were destroyed in order to rid the herd of the disease. Four yearlings that had been vaccinated against brucellosis as calves and 5 new calves, which were also vaccinated, were retained.

Soon afterward, in 1964, 12 certified brucellosis-free bison (6 adult males and 6 adult females) from Theodore Roosevelt National Park (TRNP) were added to the Moran population, bringing the total number of animals to 21. The TRNP bison represented a long line of introductions from several herds (Shelley and Anderson 1989), including both mountain and plains bison. Thus the bison that make up the Jackson bison herd today are only partially of the endemic lineage, assuming that Yellowstone and Jackson bison were once of similar lineage. In 1968 the population was down to 11 adults, all of which tested negative for brucellosis, and 4 or 5 calves. Later that year the entire herd escaped the confines of the wildlife park. The herd was eventually allowed to free-range in 1969, partially as a result of recommendations contained in a report commissioned by the Secretary of the Interior on wildlife management in the national parks (Leopold et al. 1963).

After becoming free ranging, the JBH established fairly well defined movement patterns in Grand Teton National Park, spending summers in the Potholes/Signal Mountain/Snake River bottoms area and wintering in the Snake River bottoms and further south (Fig. 1). During the early 1970s, the herd wintered in the river bottoms north of Moose and in the Kelly Hayfields vicinity (Fig. 2). Since the winter of 1975-76, however, most of the herd has wintered on the National Elk Refuge (except during the mild winter of '76-77).

Since becoming free ranging, the bison herd has greatly increased in size (Fig. 3). Numbers grew slowly until 1980 when the herd began consuming supplemental winter feed (intended for elk) on the NER. Since then the herd has grown dramatically, most likely due to the tremendous energy source realized with the supplemental feed and a concomitant decrease in winter mortality. In March 1996 the herd contained approximately 255 animals.

History of Bison Management in Jackson Hole

In 1948 the Jackson Hole Wildlife Park was dedicated by the governor of Wyoming as a joint venture between the state of Wyoming, the New York Zoological Society, and the Jackson Hole Preserve, Inc. The 20 bison introduced from YNP and held there were considered property of the State of Wyoming.

In 1950, the expansion of GTNP took in the Jackson Hole Wildlife Park and management of the bison began shifting to the National Park Service (NPS). By 1963, most management was conducted by the NPS in coordination with the Wyoming Game and Fish Department. Throughout the 1960s, management actions consisted primarily of winter feeding, rounding up animals that escaped the confines of the wildlife park (which occurred several times annually), and routine brucellosis testing and vaccination.

Between 1969 and 1985 few management actions were taken. The number of animals in the herd and its sex and age composition were documented on an opportunistic basis. Soon after the bison began wintering on the NER, managers realized that they readily displaced elk from the feedlines. Efforts to haze the animals away from feeding areas took place but were largely unsuccessful. Consequently, the NER resorted to overfeeding the bison to keep them away from elk feedlines and to minimize conflicts. The U.S. Fish and Wildlife Service (USFWS) was concerned about bison wintering on the NER because of 1) increased consumption of supplemental feed and associated costs, 2) conflicts with the elk feeding program and the management guidelines for the Refuge, 3) human safety concerns near the NER visitor center, along the NER road, and in the town of Jackson when bison approached the Refuge's south entrance, and 4) property damage (e.g. fences and signs).

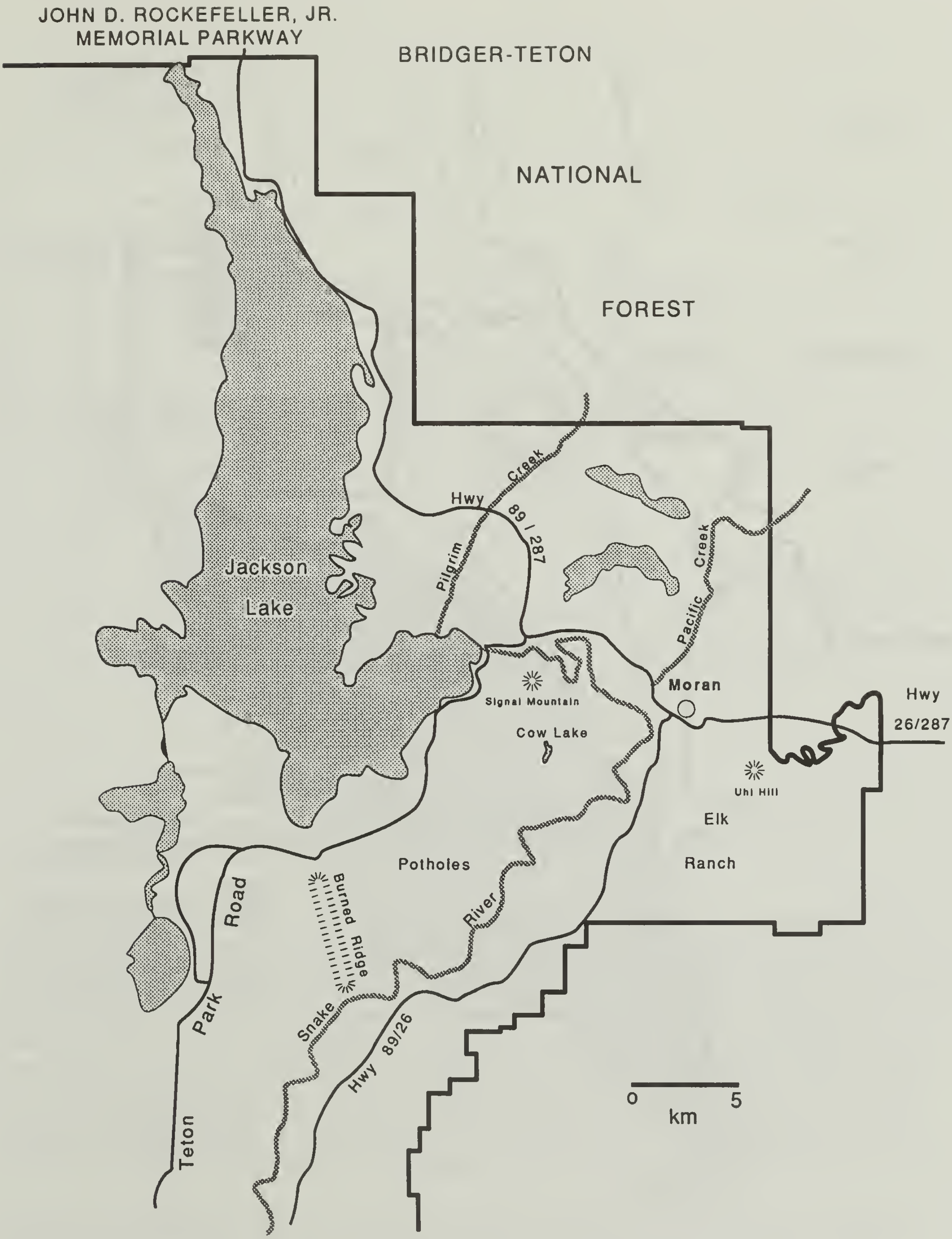

Figure 1. Northern portion of Grand Teton National Park.

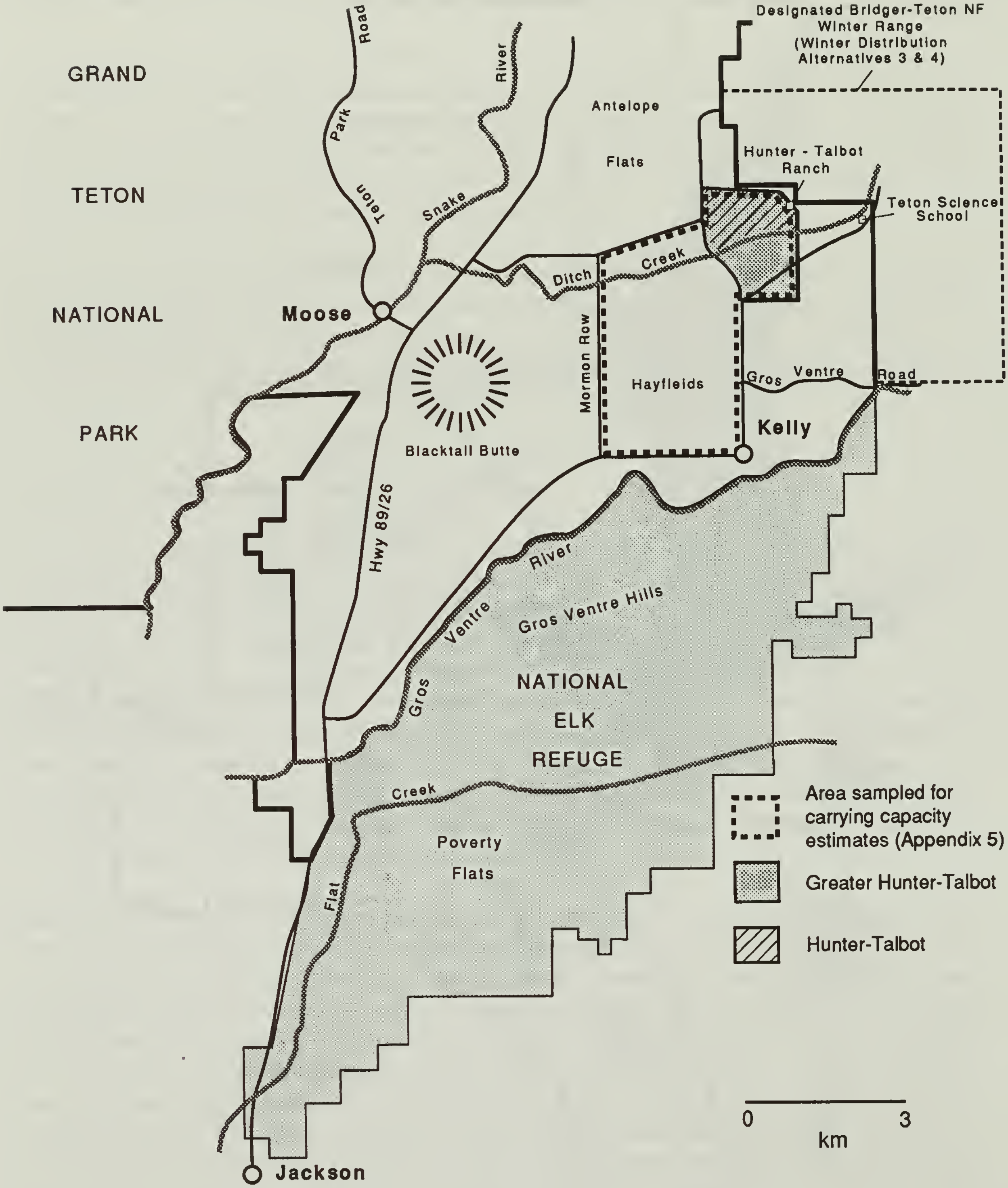

Figure 2. Southern portion of Grand Teton National Park and the National Elk Refuge.

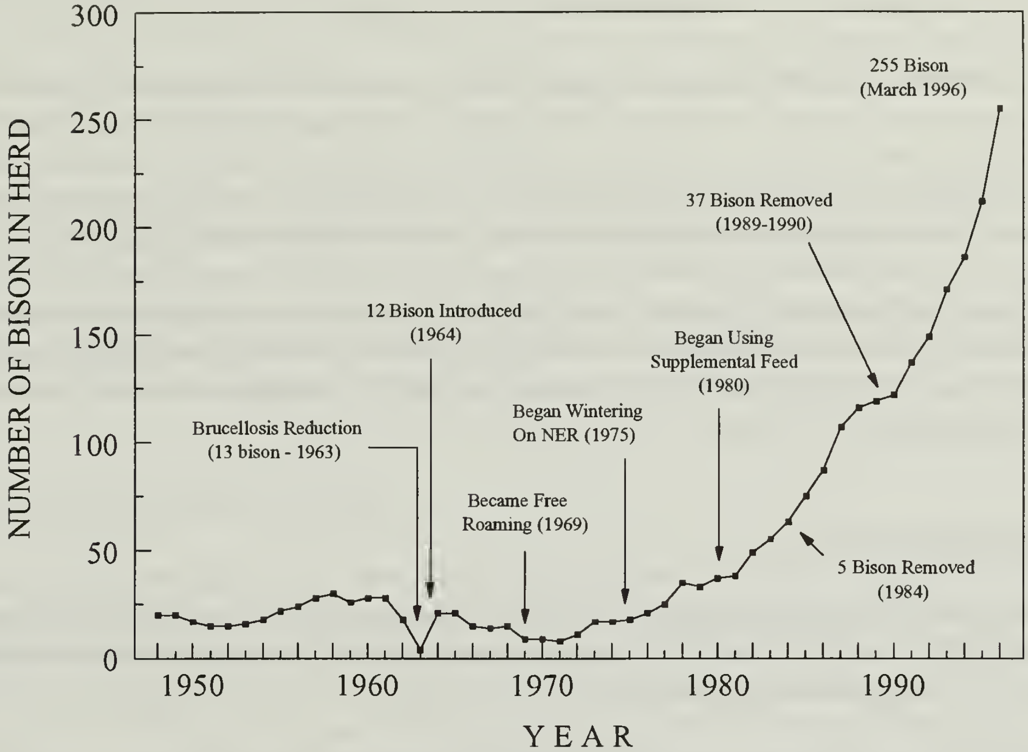

Figure 3. Population trend of the Jackson bison herd, from winter surveys 1948-1996.

During the winter of 1974-75, two bulls were killed on a private inholding in the Park by the landowner (Wood 1975). In 1979, the Wyoming Game and Fish Commission and the Wyoming Livestock Board designated bison as "wildlife" only upon federal lands in Teton and Park Counties. Under these regulations, bison could still be killed on private lands. Two bison were shot on the Twin Creek Ranch adjacent to the NER in 1987 and a single bull was shot on private land near Marbleton, Wyoming in 1988. On the NER bison were considered wild, free roaming animals with the same management options as for other ungulates under State of Wyoming regulations. During the winter of 1983-84 five bulls that had gored and killed U.S. Government horses and were a threat to visitors were killed by NER personnel.

In 1989 Wyoming Statutes 23-1-101 and 23-1-302 established the framework to designate wild bison as wildlife in Wyoming and a species subject to regulations promulgated by the Commissioners. Regulations issued by the Wyoming Game and Fish Commission and the Wyoming Livestock Board designate bison as wildlife on federal lands within the Shoshone and Teton National Forests in Park County and on federal lands in Teton County north of U.S. Highway 89 and 189-191 north of Hoback Junction. These regulations give the Wyoming Livestock Board the authority to determine bison on other public or private lands a threat to livestock health or improvements and require their removal by the Commission or its designee. The regulations also authorize a wild bison reduction season.

Today the land and wildlife management agencies in Jackson Hole view bison as a native wildlife species and, as such, a desirable component of the local ecosystem. Bison have strong public support, both locally and nationally. They are considered an asset to Jackson Hole's ecological integrity and recreational opportunities. Feeding costs, property damage, human safety, and other management concerns previously viewed as "problems" are now more appropriately considered routine wildlife management challenges. There is one strong exception to this generality, however. The issue of the disease brucellosis (which some bison carry) and its potential transmission from wildlife to livestock has escalated during the last decade, putting agricultural and wildlife interests at odds. This issue is discussed in much more detail throughout this plan.

Bison Management Plans

In 1986 the WGFD prepared an in-house bison management plan for the JBH that called for a free-ranging herd of approximately 50 animals to be maintained through various reduction alternatives. This plan was never implemented.

In 1987, due to increasing bison management concerns related primarily to winter distribution, the U.S. Fish and Wildlife Service-NER and National Park Service-GTNP prepared a management plan/environmental assessment for the JBH that also called for maintaining a free-roaming population of approximately 50 animals. Essentially, this federal plan recommended implementing the WGFD 1986 management plan. At that time the herd contained approximately 90 animals. Public response to the plan was varied (see Appendix II), with no general consensus for any one of the alternatives. The plan was also criticized for lacking a scientific basis for the recommended herd size. Following an analysis of the public comments, the agencies decided to retract the document and develop an "interim" bison management plan. The interim plan was intended to guide management of the herd during a several-year interim period during which additional scientific and other information would be gathered to provide a solid base for a long-term management plan.

The "Interim Agreement for Management Of The Jackson Bison Herd," covering the period September 1, 1988 to December 31, 1994, was released in 1988 and was sponsored by the NER, GTNP, WGFD, and BTNF. This agreement called for maintaining the herd at 90-110 animals through various reduction alternatives. Under this agreement, reductions were accomplished by agency personnel in the winter of 1988-89 and by sport hunters in 1989-90 and 1990-91, removing a total of 37 animals.

The reduction of 1990-91, which called for the removal of 12 animals, was discontinued when a lawsuit was filed against the U.S. Fish and Wildlife Service by Legal Action For Animals, a New York-based animal activist group. Only two bison were killed before the reduction was stopped. The suit opposing the hunt cited the agency with failure to follow proper National Environmental Policy Act (NEPA) processes before implementing a major federal action. Subsequently, the defendants and plaintiffs came to an out-of-court agreement to halt all bison reductions until completion of an environmental assessment and approved long-term management plan for the Jackson herd.

In November 1994, GTNP, NER, WGFD, National Wildlife Health Center, and BTNF released a draft long-term management plan and environmental assessment for the Jackson bison herd (USDI-NPS et al. 1994). Public comments were accepted during a 30-day comment period, which was extended for an additional 45 days (75 days total). The results of the public comments analysis for the 1994 draft plan (Appendix IV) and other developing bison management issues formed the basis for the preparation of this plan.

Recent Research and Herd Status

Although monitoring of the herd was opportunistic for many years, the agencies have made concerted efforts to assess its status annually since 1984. During the past 12 years, the sex ratio of the herd has been approximately equal, and calves have ranged from 14-18% of the population. The majority of known mortalities have been caused by collisions with automobiles in GTNP (1-3 per year), followed by winter mortalities on the NER (1-3 per winter). Other naturally occurring mortalities are probably never documented. During the summer of 1990, one certified brucellosis-free, yearling female bison was introduced into the Jackson herd from the Wind Cave National Park herd. This animal was brought in to address genetic concerns. Unfortunately, she died of unknown causes on the NER during the 1991-1992 winter approximately 18 months after her introduction to the herd.

Several studies related to aspects of bison ecology in Jackson Hole have been undertaken during the interim management period. These include: 1) a radio-telemetry study to determine seasonal distribution and migration routes of bison, conducted by GTNP personnel from 1987 - 1989; 2) a study of interactions of bison and elk on the NER conducted by a graduate student from Utah State University during the winter of 1988-89 (Helprin 1992); 3) a scientific review on genetic management of small herds and sterilization as a herd management technique conducted by the U.S. Fish and Wildlife Service Cooperative Wildlife Research Unit in Laramie, Wyoming (Shelley and Anderson 1989); 4) a bison calving timing and distribution study conducted by GTNP during 1991 and 1992; and 5) an assessment of the Jackson bison population as it relates to management and conservation issues in demography and genetics (Berger 1996).

Present Conditions

The JBH is currently managed jointly by the NER, GTNP, WGFD, and BTNF in the spirit of the conditions established in the 1988 interim agreement. Herd reductions have not taken place since the 1990-91 reductions were discontinued as a result of legal action. The National Wildlife Health Center-Bozeman Station, a former U.S. Fish and Wildlife Service unit now under the National Biological Service, provides GTNP and the NER with disease management expertise and support.

Radio-telemetry studies have shown that the Jackson bison have very consistent seasonal distributions and movements (GTNP unpublished data; Fig. 4). The herd winters largely on the NER. During supplemental feeding operations for elk, which usually take place for approximately 3 months each winter, the bison are fed liberally to minimize disturbance of elk feeding operations. After supplemental feeding on the NER is discontinued in late winter or early spring, the bison herd moves to the northern end of the NER and the southern end of GTNP. During April and May, the herd typically is found in the vicinity of the Kelly Hayfields, Hunter-Talbot area, and Teton Science School, as well as on the northern edge of the NER. Small areas of the BTNF near Shadow Mountain and Ditch Creek are also used occasionally. Much of the Kelly Hayfields and Hunter-Talbot area is composed of previously cultivated agricultural crops (primarily smooth brome and alfalfa). Northward migrations through Antelope Flats and the Snake River bottoms continue to primary summering areas during May and June. The majority of calving takes place between mid-May and mid-June, and calves may be born on spring or summer ranges (GTNP unpublished data).

Most of the herd spends the summers in sagebrush (Artemisia spp.)-grassland areas in the Potholes, around Cow Lake, and along the Snake River between Deadman's Bar and Moran, where cottonwood (Populus spp.)-spruce (Picea spp.) riparian areas are also used. Occasional movements into the lower drainages of Pacific Creek and Pilgrim Creek are also observed, and a few animals (usually older bulls) can be found outside their primary range in the Uhl Hill and Elk Ranch Flats areas at times during the summer. In July and August, large numbers of bison often congregate along Highway 287 just south of Moran where they are a significant tourist attraction. Cows, calves, subadult males and some adult males are quite gregarious throughout the year and rarely stray from well-defined seasonal ranges. Older adult males, however, often become solitary, especially during the summer, and are occasionally observed outside of these areas. It was speculated that a total of 6 adult male bison found wandering near Marbleton, WY in 1988 (1), and Cora, WY in 1990 (3) and 1992 (2) were from the JBH.

During late August and through September bison begin moving south along the same migration routes used during spring. Typically large numbers of bison are present in the Mormon Row-Kelly Hayfields/Hunter-Talbot area throughout September and October. Movements to the NER are not uncommon during this time. The herd uses all of these areas throughout the fall, and may remain in GTNP into November during some years. Generally, the majority of the herd has moved to the NER for the winter by December. At the NER,

Figure 4. Seasonal range and migration route of the Jackson bison herd.

bison subsist on native winter range until supplemental feeding for elk begins, which is usually in late January.

Currently, management actions revolve around basic monitoring and the collection of biological samples from animals that are found dead. Annual age and sex classifications are conducted at the NER in winter and within GTNP during summer.

Information about the prevalence of brucellosis in the JBH has come primarily from samples taken from bison killed during herd reductions from 1989-1991. Data from 35 bison taken during the reductions indicate 77% tested positive or suspect for Brucella antibodies (See Appendix VIII). A 95% confidence interval for seroprevalence ranged from 64-88% (Williams et al. 1993). The relationship between seroprevalence and herd infection rate is unknown, but the following data provide the only approximation available for the JBH. Tissue samples from 16 (11 seropositive) of the 35 bison were collected and cultured for brucellosis. Four of the 11 (36%) seropositive bison were culture positive for Brucella abortus. These results suggest a minimum infection rate of 27% for this small sample. Additional information on brucellosis is presented in the Management Issue IV: Disease Management Alternatives section and in Appendix VII.

Bison play an important ecological role in Jackson Hole and are recognized as a vital element of the native biota. Prior to the re-establishment of bison in Jackson Hole, the community of large, native herbivores that evolved with the landscape was incomplete. Today, bison, moose, elk, deer, and pronghorn can interact with one another and their environment dynamically, much as they did for thousands of years (given the limitations that contemporary human occupation of the area incurs). Bison represent an important component of the extraordinary natural ecosystem processes that are part of Jackson Hole, and in that context they have intrinsic value. Furthermore, bison are the largest land mammal in the New World, and to many they symbolize the American West.

Bison are also an important tourist attraction. When their movements bring them to areas accessible by large numbers of people, traffic or "bison jams" are common. These usually occur along Highway 287 south of Moran, near the lower Pilgrim Creek Flats, and near the Potholes overlook on the inside GTNP road. Because of their popularity with tourists, the Jackson Lake Lodge Company, GTNP's largest concessionaire, maintains a "Where the Buffalo Roam" billboard to assist visitors with observing bison during the summer. Unlike Yellowstone National Park where several serious injuries to visitors have occurred, only one human injury has been attributed to the JBH to date. This is probably due, in part, to their favored summer and winter ranges that make them less visible and accessible to large numbers of tourists than bison in Yellowstone.

The Brucellosis Issue

Brucellosis (specifically bovine brucellosis) is a significant component of the Jackson Bison Herd Management Plan and Environmental Assessment because of the national and international economic importance of the disease to the livestock industry. U.S. Department of Agriculture (USDA) statistics (in 1992 dollars) estimate the value of U.S. cattle at $60-70 billion, with over $3 billion in the 3 states of Montana, Wyoming, and Idaho. Cattle in the U.S. generate over $44.5 billion in meat and milk production yearly.

The USDA initiated the brucellosis eradication program in 1934 when about 5% of herds nationally were infected with the disease. As of May 31, 1996, only 45 herds (in 7 states) were quarantined for brucellosis (USDA records). Thirty-four states are classified as brucellosis-free and have restrictions on importation of cattle from areas with infected herds. The remaining 16 states are class A (defined as areas where the infection rate for cattle and domestic bison herds has not exceeded 0.25% during the previous 12 months), with brucellosis-free classification pending for 9 of these in the coming year (Frye and Gilsdorf 1995). Brucellosis-free classification opens foreign and domestic markets and eliminates the need for costly testing before transport. In addition, eradication of the disease eliminates the need for the additional expense of vaccination and indemnity. In 1995 in the U.S., 12.5 million cattle were tested, 6.7 million calves were vaccinated and the eradication program paid $3.5 million in indemnity (Frye and Gilsdorf 1995).

In recent years the combined state and federal brucellosis eradication program costs have been around $156 million per year. Congressional pressure and success of the program have resulted in a target date of 1998 to complete brucellosis eradication in domestic cattle. Once brucellosis has been eliminated from domestic cattle, brucellosis in wildlife of the Greater Yellowstone Area will be the only remaining focus of the disease in the U.S. This creates two issues of concern to agricultural interests. First, wildlife infected with Brucella abortus pose a potential source for reintroduction into cattle. The magnitude of that risk is a debated topic, but from an agricultural perspective it requires maintenance of a costly monitoring, surveillance and protection program for livestock. Second, regardless of the actual risk and the ability of agricultural and wildlife agencies to manage that risk, the perception of risk, created by the presence of brucellosis in bison and elk of the GYA, exists in brucellosis-free states and countries. That perception is believed to play a significant role in negatively affecting the marketing of Wyoming, Montana and Idaho cattle.

In 1990 the Governor of Wyoming appointed a task force to recommend policies for addressing brucellosis in wildlife. From these recommendations came a Memorandum of Understanding (MOU) among the states of Wyoming, Idaho, and Montana and the U.S. Departments of Interior and Agriculture creating the Greater Yellowstone Interagency Brucellosis Committee. The committee's stated goal is to protect and sustain the existing free-ranging elk and bison populations in the GYA and protect the public interests and economic viability of the livestock industry in the three states. The organization is comprised of an executive committee, a technical subcommittee, and an information and education subcommittee. The GYIBC is designed to provide direction and coordination of agency responsibilities for the purpose of brucellosis management in the GYA.

Since its inception in 1994, the GYIBC's Executive Committee has held quarterly meetings, preceded by meetings of its Technical and Information & Education subcommittees. As of July 1996 these committees had achieved the following:

1) Organized and held a National Brucellosis Symposium in Jackson, Wyoming in September 1994.

2) Developed a position statement that discourages supplemental feeding of wild ungulates due to the link between artificial feeding of elk and bison and the maintenance of brucellosis in those species in the Greater Yellowstone Area.

3) Developed informational reports on the risk of transmission of brucellosis from infected bull bison to cattle, and on recommended bison quarantine procedures should herd reductions/disease control occur via capture and donation of live bison.

4) Identified research needs pertaining to brucellosis management. Some of these topics are currently being pursued by researchers.

5) Developed a number of public informational and educational materials on the brucellosis issue in the Greater Yellowstone Area, including an action plan for increasing public information and involvement, and a question and answer handout about brucellosis. A white paper on the brucellosis issue is near completion.

6) Initiated development of a database on all elk and bison herds in the GYA. This will be used to develop herd management plans for minimizing the risk of brucellosis transmission to cattle.

7) Developed a task directive, schedule, and budget for preparation of a GYA brucellosis management Environmental Impact Statement. Funding is currently being sought to initiate this 4-year effort.

Agency Policies and Mandates

National Park Service. NPS management policies originate primarily from the 1916 Organic Act of the National Park Service (16 U.S.C. 1), which mandates that one of the purposes of parks is to manage park wildlife "....by such means as will leave them unimpaired for the enjoyment of future generations." Several National Park Service policies apply to management of the Jackson bison herd. These policies, which follow, are contained in Management Policies (USDI-NPS 1988).

> The National Park Service will seek to perpetuate the native animal life as part of the natural ecosystems of parks. (Chapter 4:5)
>
> Ecological processes altered in the past by human activities may need to be abetted to maintain the closest approximation of the natural ecosystem where a truly natural system is no longer attainable. (Chapter 4:2)
>
> Natural processes will be relied on to control populations of native species to the greatest extent possible. Unnatural concentrations of native species caused by human activities may be controlled if the activities causing the concentrations cannot be controlled. (Chapter 4:6)
>
> When individual plants or animals must be removed for any reason--hunting, fishing, pest management, or culling to reduce excess populations resulting from human activities--the National Park Service will consider the need to maintain appropriate levels of genetic diversity in the residual park populations. (Chapter 4:10)
>
> Hunting and trapping wildlife will be allowed only in parks where such use is specifically authorized. (Chapter 4:7)

Additional guidance on animal management is contained in NPS-77, Natural Resources Management Guideline, (USDI-NPS, 1991). NPS guidelines generally allow for management discretion in applying policy, and are mandatory only where the language so indicates. Guidelines applicable to bison management at Grand Teton National Park include the following:

> Habitat manipulation (for managing native animals) may also be used when recreating or simulating a natural feature, natural process, or parameters of critical habitat, and in cases where factors or conditions are no longer present to accomplish this without management intervention. (Chapter 2, page 32)
>
> Supplemental feeding may not take place unless it is part of an approved resource management plan and for the recovery or maintenance of a threatened or endangered species or a species of concern. Even under these circumstances feeding should last for no longer than is necessary to compensate for the identified deficiency. (Chapter 2, page 41)
>
> Species of Concern: All native species within a park that face an immediate danger of losing their natural role in an ecosystem because of human-induced change. (Chapter 2, page 20)

The above listing of policies and guidelines is of primary importance to bison management, but is not all-inclusive. Other related policies and guidelines may also apply.

The Grand Teton National Park Master Plan (1976) states that biotic resources will be managed as near natural dynamic equilibrium as is feasible, and the wildlife will be displayed under conditions that are natural and unrestrained.

U.S. Fish and Wildlife Service. U.S. Fish and Wildlife Service policies from the USFWS Refuge Manual that pertain to bison are as follows:

> 7 RM 7.1: Policy. Management practices for other resident wildlife on national wildlife refuges will emphasize the protection of breeding stocks and the production of wildlife to achieve a diversity of those species which naturally occur or historically occurred on the refuge. The special interest of the various states in the management of resident animals is recognized and refuge management and refuge management actions for those species will be coordinated with State management objectives, where possible.
>
> 7 RM 7.3: Definition. "Resident Wildlife" means those wildlife species commonly considered as upland game, big game, small game, furbearers, predators, or non-game species and not considered under the following categories:
>
> -- migratory birds
> -- officially listed threatened or endangered species
> -- buffalo, longhorns, wild horses and burros
> -- feral animals (goats, hogs, etc.)
> -- introduced (non-native) species
> -- marine mammals
> -- fish

From the Manual's section on fenced animal management:

> 7 RM 5.2: Policy. The Service will maintain remnant herds of nationally and/or historically significant animals on those refuges established for that purpose, to ensure their continued existence in numbers sufficient to perpetuate the associated cultural, scientific, and aesthetic values. Bison and Texas longhorn cattle will not be introduced onto any National Wildlife Refuge except those listed for these species in Section 5.1 above. Section 5.1 lists only four refuges: the National Bison Range in Montana, Wichita Mountains Wildlife Refuge in Oklahoma, Fort Niobrara National Wildlife Refuge in Nebraska, and Sully's Hill National Game Preserve in North Dakota.

Applicable USFWS policies specific to the National Elk Refuge include the following:

- Bison will not be confined by fencing or by other means on any portion of the National Elk Refuge.

- The Service shall minimize, to the extent possible and practical, the use by bison of supplemental feed provided in winter to elk.

- Because of the potential for interspecific transmission of diseases fostered by close association of infected and susceptible animals, the Service shall minimize concentration and intermingling of bison and elk on the National Elk Refuge.

- Bison that do winter on the Refuge will be restricted to lands north of Flat Creek by hazing, or in situations where they become a threat to human health and property, by destruction.

State of Wyoming. Two regulations promulgated by the State of Wyoming are particularly applicable to management of the JBH. Chapter XLI of the Wyoming Game and Fish Commission and Wyoming Livestock Board Regulations designates bison as wildlife on federal lands within the Shoshone and Teton National Forests in Park County and on federal lands in Teton County north of U.S. Highway 89 and 189 - 191 north of Hoback Junction (Wyoming Game and Fish Commission 1989). This regulation gives the Wyoming Livestock Board the authority to determine bison on other public or private lands a threat to livestock health or improvements and require their removal by the Commission or its designee. Chapter XV authorizes and determines the structure and process for implementing a wild bison reduction season (Wyoming Game and Fish Commission 1991).

U.S. Forest Service. The U.S. Forest Service, under the U.S. Department of Agriculture, has multiple Forest Service and USDA direction with respect to the JBH. Authorities, objectives, policies, and other direction guiding management of the JBH are listed in full in Appendix I. In general, the U.S. Forest Service recognizes the State as being responsible for wildlife while the Forest Service provides habitat capable of meeting population objectives (USDA-FS 1991).

Table 1. Matrix table of alternatives by management issues identified for the Jackson Bison Management Plan. For each management issue, the preferred alternative is highlighted.

SUMMARY OF MANAGEMENT ISSUES AND ALTERNATIVES

Management Issue	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7
Herd Size	No Action The herd would be allowed to self-regulate, possibly reaching a population size of over 1,000 before levelling off	90 - 110 The herd would be maintained at the 1988 Interim Management Plan level	**200-250** **The herd would be maintained at the minimum level necessary to protect heterozygosity, possibly exceeding 200 if a portion of it wintered off of the NER**	350-400 The herd would be allowed to grow to 350-400 bison, providing an effective population size of 100 without induced immigration	N/A	N/A	N/A
Herd Reduction Methods	Sterilization or Contraception Animals would be sterilized or treated with a reversible contraceptive to maintain a given herd level	Agency Reductions Agency personnel would remove bison on the NER and sell or donate carcasses	Public Hunt Reduction Bison would be removed by sport hunters through WGFD on NER or BTNF lands	Trap and Transport to Quarantine Bison would be trapped, tested for disease, and transported to quarantine facility if disease-free or tagged and released if test-positive	Native American Hunt Reduction Native Americans would be allowed to harvest and keep animals from the herd	Trap, Test & Slaughter Bison would be trapped, tested for disease, and killed if test-positive. Carcasses would be sold or donated.	**Public Hunt / Reduction for Native American** **Public "fair-chase" hunt would remove 5-10 bison; remainder would be made available to Native Americans**
Winter Distribution	No Action Bison would continue to winter on the NER and consume supplemental elk feed	Fence At Hunter-Talbot Bison would be herded into a fenced enclosure in GTNP during winter and possibly supplementally fed	Feed At Hunter-Talbot - No Fence Bison would be supplementally fed during winter in GTNP to keep them away from NER feedlines	**Modify Distribution Through Baiting** **Bison would be baited at the Hunter-Talbot to try to modify winter distribution**	Fence Within Enclosure at NER Bison would be herded into a fenced enclosure on the NER during winter and possibly supplementally fed	N/A	N/A
Disease Management	No Action No action to control or eliminate disease from the herd would be taken	Test and Removal Bison would be rounded up, tested for disease, and removed from the population if infected	Vaccinate Bison would be vaccinated against brucellosis with Strain 19	Depopulate The entire population would be removed and then restocked with disease-free bison	**Minimize Contact** **Contact between bison and cattle would be minimized, new vaccine used, and risk assessment done**	N/A	N/A

PREFERRED ALTERNATIVES

MANAGEMENT ISSUES AND ALTERNATIVES

In this section each of the management issue alternatives are presented and briefly described. The impacts associated with the alternatives are described later under ENVIRONMENTAL CONSEQUENCES.

MANAGEMENT ISSUE I: HERD SIZE

Herd size is the most important and potentially far reaching of all the management issues because of its effect on all other issues. It directly affects the scope and magnitude of herd reductions, determines bison impacts on winter range, affects the potential for disease transmission to domestic livestock, influences recreational opportunities for viewing bison, and alters the genetic variability present in the herd over time. Not surprisingly, this has been the single most controversial issue and the focal point of all management plans and discussions in the past.

The alternatives analyzed under Herd Size have changed since the 1994 draft plan. The alternative of 150 bison, which was based on genetic recommendations in Shelley and Anderson (1989) was dropped because of new, empirical genetic information on wild bison suggesting that a herd size of 150 is too low (Berger 1996, Berger and Cunningham 1994). Accordingly, the previous 150 - 200 herd size alternative was revised to the current 200 - 250 herd size alternative. In addition, a new alternative of 350 - 400 was added to the analysis in the current plan. This alternative was added because comments received on the 1994 draft indicated high public interest in herd sizes greater than 200 and less than the herd size projected under the unlimited growth alternative (Appendix IV).

Herd Size And Genetic Considerations

Long term population genetic variability, which affects population fitness, is strongly influenced by population size and rates of immigration (the addition of animals from other populations). For genetically isolated populations, as population size decreases, inbreeding coefficients and the potential for associated deleterious effects on fitness increase. The effective population size, N_e, is an ideal measure of expected levels of genetic variability over time, with higher N_e's inferring slower losses of genetic variability. For populations that are not isolated, periodic immigration increases N_e.

In a review of genetic considerations for genetically isolated bison populations, Shelley and Anderson (1989) recommended a minimum herd size of 150, assuming that N_e was 33% of the total population size (for an N_e of 50) and that the population met several conditions that are unlikely to occur in the wild. Their recommendations were based on genetic theory.

More recently, however, Berger and Cunningham (1994) provided empirical evidence that N_e varied from 15-34% in a Badlands National Park wild bison population with demographic attributes similar to the JBH. Furthermore, Berger (1996) suggested that managing for an N_e of 50 may not be prudent and that maintaining an N_e of 100 may be considered more of a "mid-range" goal.

In consideration of the above and for the purposes of genetic analyses in this plan, N_e will be assumed to be 25% of the total population, which is an average of Berger and Cunningham's (1994) 15-34% estimate, and the goal will be to manage for an N_e of 100. Recognizing that immigration can have a marked effect on N_e, Berger (1996) estimated the effects of induced immigration (translocating bison from other populations to the JBH) on N_e for varying levels of immigration and herd size. These estimates are reprinted here in Table 2 and will be referred to throughout the plan where issues of herd size as it relates to genetic concerns are discussed.

Table 2. Projected effective population sizes in bison with a mean N_e/N of 0.25, assuming a bison generation is 6.75 years (from Berger 1996).

Immigrants	Herd Size						
Per Generation	100	150	200	250	300	350	400
0	25	38	50	63	75	88	100
1	30	45	60	75	90	105	120
2	33	50	66	83	99	116	132
5	54	82	108	136	164	192	220
7	81	123	162	204	243	285	324

Alternatives Considered But Rejected:

1. A population size of zero, or eliminating the JBH, was judged to be unacceptable due to the managing agencies' mandates and goals and the overwhelming support bison have among the public. Thus this alternative was dropped from further analysis.

2. The first two management plans written for Jackson Hole bison by WGFD and USFWS/NPS called for maintaining a population of approximately 50 animals. This proposed herd level received little support during review of the 1988 Environmental Assessment and no support in the comments received on the May 1991 scoping statement. This number is also inconsistent with current scientific knowledge of minimum herd levels necessary to maintain genetic variability (Shelley and Anderson 1989, Berger 1996). Consequently, this alternative was also rejected from further analysis.

3. Specific herd levels in excess of 400 animals were considered but rejected from analysis for a number of reasons. First, a population of 400 would have an estimated N_e of 100 (Table 2),

which would, without induced immigration, provide for maintaining levels of genetic variability commensurate with accepted standards of conservation biology (Berger 1996). Second, forage production sampling in areas that bison would be most likely to use if they wintered away from elk feedlines on the NER indicate these areas could support approximately 210 animals in an average winter, assuming bison will use these areas consistently throughout the winter (see Management Issue III: Winter Distribution Alternatives for further discussion). As the herd becomes larger, other concerns arise, including potential range degradation if the bison do not find and use additional winter ranges, impacts on other wildlife species, and range expansion and/or emigration, which could increase the potential for brucellosis transmission from bison to cattle (see Management Issue IV: Disease Management Alternatives). If bison continue to winter on the NER, larger herd sizes also would mean increased costs associated with supplemental feeding.

Herd Size Alternative 1: No Action

Under this alternative, no management actions would be taken to manipulate the number of animals in the herd. The herd would essentially be allowed to self-regulate, and individuals would be removed from the population only if they represented an immediate threat to human life or property. Based on growth rates of the JBH over the last 16 years, a logistic population growth model suggests that a self-regulating herd would grow until reaching about 1100 animals before leveling off (see Fig. 5). Since the herd could be affected by factors not accounted for in growth models, however, the ultimate size it would obtain is unknown.

Herd Size Alternative 2: Herd Size of 90-110

This alternative would replicate the management of the herd under the 1988 interim management plan. The herd level would be maintained by one or more of the herd reduction alternatives considered for analysis under Management Issue II: Herd Reduction Methods.

To compensate for the potential loss of alleles (i.e. heterozygosity) at a herd level of 90-110, periodic introductions of bison from other herds would be necessary (Shelley and Anderson 1989, Berger 1996). To maintain an estimated N_e of 50, a recommended minimum, approximately 5 female bison would have to be introduced every 7 years. To maintain an estimated N_e of 100, the agencies' goal for protecting genetic variability, more than 7 bison would have to be introduced to the population each generation (Table 2). Female bison would be the best candidates for introductions because males have a higher reproductive variance (Shelley and Anderson 1989, Berger 1996). Introduced animals would have to be permanently marked to allow monitoring of their reproductive rates and thus their genetic contribution. Ideally, offspring from the introduced animals would be permanently marked as well.

Herd Size Alternative 3 : Herd Size of 200 - 250 (PREFERRED ALTERNATIVE)

This alternative would maintain a minimum of 200 and potentially up to 250 bison in the JBH. It is based on 1) maintaining genetic variability through herd size and induced immigrations (Shelley and Anderson 1989, Berger 1996), 2) available forage estimates on desirable winter ranges, 3) maintaining opportunities for public enjoyment of bison, 4) maintaining the intrinsic ecological value of bison in Jackson Hole, and 5) minimizing risk of disease transmission to domestic livestock. The ultimate number in the herd would depend on the number of bison that wintered off of elk supplemental feedlines on the NER.

A "sliding scale" concept would be used to determine the herd level, based on the relative numbers of bison wintering on and off of NER feedlines as follows: the formula X = 200 - 0.80Y would be used to determine the herd level, where X equals the maximum number of bison on the NER feedlines and Y equals the number of bison wintering on native vegetation. The formula was derived to diminish the number of bison permitted to use supplemental feed provided to elk at the NER, as the number of bison wintering elsewhere increased, until no bison would be permitted to use supplemental NER feed when 250 bison winter elsewhere. Thus the constant, 0.80, was selected to derive zero bison permitted on NER feedlines when 250 bison (the upper population level in the Preferred Herd Size Alternative) winter elsewhere. Table 3 provides an example of herd sizes based on this formula and herd distribution.

Table 3. Examples of winter distribution-dependent maximum herd sizes based on the formula X=200-0.80Y.

Number Wintering Off Refuge Feedlines (Y)	Number Wintering On Refuge Feedlines (X)	Total Herd Size
0	200	200
50	160	210
100	120	220
150	80	230
200	40	240
250+	0	250+

Note that when 200 or more bison winter away from Refuge feedgrounds, the total JBH size will be determined by carrying capacity of winter ranges they occupy.

This alternative would be closely tied to either Alternative 3 or 4 under Winter Distribution Alternatives. Together these alternatives would have a primary objective of establishing bison wintering areas away from supplemental feedlines on the NER where 1) bison would subsist on natural winter forage, and 2) bison would be separate from concentrated elk herds where disease transmission likely occurs. Numbers in excess of 200 would be permitted dependent upon the success of wintering bison away from the feedlines, but a minimum of 200 would always be maintained.

Under this alternative, the WGFD would establish a formal herd objective of 200-250 animals. Reductions would then take place only if the average number of bison wintering on the NER feedlines was greater than that determined to be acceptable by the sliding scale. At no time would reductions take place when the herd numbered 200 or fewer animals, regardless of their distribution. The intent is to eventually eliminate bison use of supplemental feed provided to elk on the NER.

Reductions would be accomplished by one or more of the herd reduction alternatives being considered under Management Issue II: Herd Reduction Methods. Reductions would attempt to focus on animals with a tendency to move toward the south end of the NER (i.e. south of the Gros Ventre Hills), the goals being 1) to discourage animals from using the south end of the Refuge where supplemental feeding occurs, and 2) to remove bison that migrate to the NER early in the fall. Bison reduction activities would take place only outside of GTNP on NER and BTNF lands (but not on the designated bison winter range on the BTNF east of the Hunter-Talbot; see Figure 2). This could result in herd numbers higher than 250 if large numbers of bison remained in the Park year-round.

To maintain an N_e of 100, the agencies' goal for protecting genetic variability, approximately 3-5 female bison would be introduced from other populations every 7 years (Table 2). Introduced animals would be permanently marked (radio-collared) and their reproductive performance (genetic contribution) monitored by 1) documenting reproductive success or failure, and 2) permanently marking offspring and monitoring their reproductive performance.

This alternative was designed to represent an effective compromise among the many factors that affect herd size determinations, including ecological, genetic, disease, socio-economic, and political concerns.

Herd Size Alternative 4: Herd Size of 350-400

Under this alternative the herd would be allowed to grow to and be maintained at approximately 350 - 400 bison. When and if herd reductions were necessary, they would be accomplished by one or more of the herd reduction methods discussed under Management Issue II: Herd Reduction Methods. Maintaining the herd at 400 bison would provide an N_e of 100, the agencies' goal for protecting genetic variability, without induced immigration, and thus provide for maintaining levels of genetic variability commensurate with accepted standards of conservation biology (Berger 1996). This alternative was not included in the 1994 Draft Plan. It was added in the final plan 1) to reflect more current knowledge of genetic considerations and 2) in response to public comments on the 1994 Draft Plan, to allow for the analysis of potential impacts associated with a significantly greater bison presence in the valley than has occurred in recent times.

MANAGEMENT ISSUE II: HERD REDUCTION METHOD ALTERNATIVES

A variety of methods could be used to reduce the size of the Jackson herd when necessary. When and if herd reductions are deemed necessary, and regardless of which methods are used, culls would be specifically designed to ensure an approximately equal sex ratio and age ratios that approximate natural conditions among the remaining members of the herd. Equal sex ratios maximize the number of potential breeders in the population and thus maximize the maintenance of genetic variability (Berger 1996).

Under direct removal alternatives, the number of animals removed from the population during any year would depend on the population objective. Assuming an annual finite rate of increase of 0.16, which is based on observed growth rates in the herd, to maintain a population of 90-110 animals approximately 14 -16 bison would have to be removed annually. To maintain a population of 200 approximately 32 animals would have to be removed annually. At populations of 250 and 400, around 40 and 64 bison respectively would be removed annually. Culling to maintain a population of 90-110 would require strict selection to avoid excessive harvest of any one age class. This would be especially true of older age class males. Culling from higher population levels would offer more flexibility in selecting individuals for removal without adversely affecting genetic variability in the population (Shelley and Anderson 1989). It is anticipated that individuals from all age classes would be selected for removal at equal sex ratios.

Alternatives Considered But Rejected:

None.

Reduction Alternative I: Sterilization or Contraception

Inhibiting reproduction through sterilization or contraception has been used on an experimental basis in a variety of wildlife populations (Denver Wildlife Research Center et al. 1993, Garrott 1995, Kirkpatrick and Turner 1985, Turner and Kirkpatrick 1991). Numerous contraceptive techniques have been tested, some in free-ranging wildlife populations. While many of these treatments have been shown to control fertility in individuals, effective long-term control of wildlife populations through reproductive inhibition has yet to be demonstrated in field trials (Garrott 1995).

Research into biochemical contraceptive techniques for ungulate populations has focused on white-tailed deer and on feral horses and burros. Because biochemical contraception has never been used for bison, and no chemical or immunocontraceptive has yet been shown to be effective, safe, and reversible for bison, more research and testing would be needed before this alternative could be applied to the Jackson bison herd. Development and testing of these contraceptive agents is a process requiring several years. The necessity for comprehensive testing before applying biochemical contraceptives to wild populations means that it is not realistic at this time to consider reversible contraception as a tool for controlling the size of the Jackson bison herd. Surgical sterilization is the only method currently available for reducing the population's birth rate. Reversible contraception could conceivably become an option in the future if a testing program is completed and regulatory approvals are obtained.

Questions that would need to be answered before applying biochemical contraceptives to the Jackson bison herd include efficacy and duration of different treatments, appropriate dosages, delivery techniques (capture and handling or remote delivery), reversibility, effects on ovarian morphology and other reproductive organs, and the possibility of other side effects. In addition, numerous questions remain about the potential effects of contraception on bison social structure and behavior, genetic integrity, and demographics. Potential impacts to nontarget animals would also need analysis.

<u>Contraceptive Technologies.</u> Sterilization, resulting in permanent loss of reproductive potential, can be accomplished by surgical or biochemical methods. Contraception, which can be reversible, uses biochemical means (usually steroids or vaccines) to control fertility. Both sterilization and contraception can be applied to both sexes.

Sterilization is preferred in situations where permanent fertility control is desired, since after initial treatment, repeated handling or treatment is not necessary. Reversible contraception is preferred in situations where managers wish to prevent the loss of any animal's genetic potential. Reversible fertility control programs provide flexibility in cases of unanticipated events such as high winter kills, allowing managers to withdraw the treatment to restore the population to safe levels (Kirkpatrick and Turner 1985).

<u>Surgical Sterilization.</u> Two methods of surgical sterilization, castration and vasectomy, are available for males. Both of these methods require that males are either caught and handled in pens and squeeze chutes or are immobilized with tranquilizing drugs in the field. A qualified veterinarian would be required to perform the surgery for either of these procedures.

Surgical sterilization of females is accomplished by removal of the ovaries through vaginal or flank surgery. The vaginal approach requires that females be constrained in an upright position using holding facilities and squeeze chutes. This surgery is more humane than the flank procedure but more costly because it requires the construction of holding facilities, corrals and squeeze chutes. Removal of the ovaries through the flank could be accomplished in the field without the need for holding facilities. Individual animals would be immobilized and surgery would be performed by a qualified veterinarian.

<u>Chemical Contraception.</u> The biochemical agents used for contraception are primarily natural and synthetic sex steroids and immunotropic protein and peptide antigens (Turner and Kirkpatrick 1991). Steroids have several advantages: they are relatively well researched, biologically active in most vertebrates, and effective over extended time periods (Turner and

Kirkpatrick 1991). Steroids inhibit reproduction by increasing the levels of certain hormones, or by eliminating hormone production, and can also suppress breeding behaviors. A drawback of most steroid contraceptives is their potential side effects. Any contraceptive that alters hormone levels has the potential to affect other physiological processes as well. Most, if not all, of the contraceptive agents currently under investigation can cause significant behavioral and social changes in treated animals (Garrott 1995). Surgical sterilization and steroids that prevent ovulation generally prevent the associated estrous and breeding behaviors. Some steroids, if administered when an animal is already pregnant, can delay or prevent normal parturition (Plotka and Seal 1989). Contraceptives that block fertilization can result in repeated estrous cycles, which can disrupt seasonal breeding patterns.

Another problem with using steroids for contraception is their potential to affect nontarget species. Synthetic steroids often exhibit poor biodegradability, raising the issue of possible consumption by scavengers and predators, including humans. No scientific research has evaluated the risk of secondary effects of contraceptives in the food chain (Garrott 1995).

Most of the research on biochemically sterilizing males with steroids has been focused on feral horses. Fertility rates in feral horse stallions have been reduced significantly through the use of steroids without adversely affecting the socio-sexual behavior of the animals, and normal fertility was restored in the breeding season of the following year (Turner and Kirkpatrick 1991). Hormone implants capable of blocking reproduction for 3-5 years have been developed for female horses (Eagle et al. 1992, Plotka et al. 1992).

Immunocontraception. Immunocontraception involves vaccinating an animal to cause it to produce antibodies against a protein or peptide involved in reproduction. The antibodies hinder or prevent some aspect of the reproductive process (Turner and Kirkpatrick 1991). Much of the research on the use of immunocontraceptives in ungulates has focused on preventing conception by blocking the sperm receptor sites on the egg. The contraceptive vaccine receiving the widest research attention is porcine zona pellucida, or PZP, made from the membrane that surrounds the ovum of pigs. PZP has been tested on horses, deer, and numerous species in zoos. Kirkpatrick et al. (1990) demonstrated greater than 95% inhibition of fertility in free-roaming feral mares treated with PZP vaccine via remotely delivered dart. No behavioral side effects were observed, and the effects of the vaccine were reversible after one year. A field test of the PZP contraceptive is underway on free-ranging feral horses in Nevada.

One drawback of PZP is that more than one inoculation is needed for successful contraception. In horses, two inoculations are needed the first year, and contraceptive effects can be extended by delivering an annual booster shot (Kirkpatrick et al. 1990). Research is underway to develop a single-dose vaccine capable of permanently sterilizing either males or females (Garrott et al. 1992). Studies are also being directed at developing a single inoculation form of the vaccine that will deliver from one to three years of contraceptive protection (Kirkpatrick et al. 1993).

Another serious drawback of immunocontraception is its potential to cause irreversible sterility. Although PZP-induced infertility has been demonstrated to be reversible after one season in feral horses, it is capable of altering ovarian function permanently after three years of treatment (Kirkpatrick et al. 1992). Reported side effects of PZP use in other species have included alteration in ovarian follicular growth and function, including markedly depressed estrogen secretion (Kirkpatrick et al. 1992, Paterson et al. 1992) and permanent ovary damage leading to sterility in some species (Paterson et al. 1992).

Immunocontraceptives, unlike some steroid contraceptives, do not directly affect breeding behavior. Treated animals may, however, continue to cycle and breed later than otherwise (Turner 1992), which could affect long-term patterns of behavior, social organization, and energy expenditure.

Unlike the steroid contraceptives, immunocontraceptives do not leave a residue in the flesh of the animal. Their protein nature means that they are metabolized prior to excretion or if ingested, precluding their passage through the food chain and eliminating the problem of potential ingestion by nontarget animals (Kirkpatrick et al. 1990).

<u>Delivery Systems for Chemical Contraceptives.</u> A variety of delivery systems have been developed for administering chemical contraceptives to wildlife. Steroids and immunocontraceptives can be delivered by intramuscular injection (Turner and Kirkpatrick 1986), requiring the animals to be captured and immobilized. Both can also be delivered remotely, using darts or biobullets. Both darts and biobullets can provide controlled release of contraceptives at a predetermined rate for a given period. Release periods up to 18 months are possible (Turner and Kirkpatrick 1991).

Steroids have been delivered by implanting steroid-impregnated silicone rubber polymer (silastic) rods subcutaneously or intraperitoneally (Kirkpatrick et al. 1990). Silastic implants gradually release the steroid and can inhibit reproduction for several years (Plotka and Seal 1989). Implanting the rods usually requires capture or immobilization, which is expensive and potentially dangerous to the animal. In at least one case, however, silastic implants containing a synthetic steroid and encased in biobullets were implanted remotely in black-tailed deer using a BallistiVet rifle (Jessup 1993).

Although some research is being conducted on the possibility of delivering steroid contraceptives and immunocontraceptives to wildlife orally, in baits, the problem of consumption of baits by nontarget animals has not been overcome (Rupprecht 1993). Oral administration can be unreliable and requires frequent, often daily, ingestion of the agent (Turner 1992).

<u>Application of Contraception or Sterilization to Wildlife Populations.</u> An important consideration in planning a fertility reduction program for a wild population is the number of animals that would have to be treated in order to stabilize the population at target levels. This number depends on the initial population size, the age and sex structure of the population, and

age- and sex-specific fecundity and survival rates. Simulation models have been used in several cases to address this question (Garrott 1991, Garrott and Siniff 1992, Garrott et al. 1992). Nearly all simulations have led to the conclusion that a relatively high proportion of animals must be treated to significantly reduce reproduction in most situations. Several studies suggest that rapidly growing populations may not be stabilized or reduced unless 60-80% of the animals in the population are effectively treated.

If a population is overabundant at the beginning of a treatment program, merely limiting birth rates may not be effective in reversing population growth and reducing the population. Traditional reduction techniques (culling, translocation, or hunting) may be required to reduce the population size prior to initiating a contraception or sterilization program (Garrott 1995). In addition, if the fertility reduction program allows for modest population growth to occur, then periodic culling will be required whenever the population reaches the maximum target.

The breeding system of a species is an important factor to consider in designing a fertility control program. For example, in a polygynous species like feral horses, sterilizing dominant harem stallions may not significantly reduce reproduction, if other males perform as little as 10% of the breeding (Garrott and Siniff 1992). In addition, applying fertility control to wildlife populations can have significant effects on breeding behavior and timing, which in turn affects energetic costs. In a polyestrous species with reproductive characteristics like those of feral horses, sterilizing dominant males can cause mares to cycle repeatedly until bred by a fertile male. This causes the foaling dates for the population to be seasonally shifted (Garrott and Siniff 1992).

Application of Sterilization or Contraception to Jackson Hole Bison. If an effective and safe contraceptive were available for bison, or if a sterilization program were initiated, decisions would have to be made about how many and which bison to treat. In part, this would depend on the initial herd size and on the target population size.

The question of the efficacy of sterilizing males or females depends partly on the animal's breeding structure. Bison have a polygynous system, in which one male mates with several females. Although dominant bulls do most of the breeding, subordinate males do some. Sterilizing only the dominant males probably wouldn't significantly reduce the number of births. A male-oriented contraceptive or sterilization program would effectively suppress population growth only if a large proportion of all males were treated.

In addition, sterilizing substantial numbers of males could disrupt seasonal calving patterns. Because female bison can exhibit a second seasonal estrous (Kirkpatrick et al. 1991), cows who are bred by a sterile bull during the August rutting season could become pregnant late by breeding with a fertile bull during their second cycle. These cows would give birth to late calves, which would enter winter with smaller body sizes and low nutritional reserves. An increase in calf mortality could result, especially if the bison were not eating supplemental feed.

Sterilizing large numbers of either males or females could affect the genetic integrity of the herd. Because males vary more than females in their reproductive contribution, removing some (but not all) successfully breeding males could serve to equalize the contributions of less successful breeders and could increase rather than decrease N_e (Berger 1996). Removing a large number of potentially breeding bison of either sex, however, could decrease N_e. Ideally, to maximize N_e, an even sex ratio of breeders should be maintained in the population (Berger 1996).

Although the Jackson bison herd is relatively isolated from other bison populations, three male bison from Yellowstone National Park visited Jackson Hole in winter 1995-1996. If significant numbers of Yellowstone bison were to immigrate and breed in Jackson Hole in future years, any population control achieved through contraception or sterilization could be compromised.

Reduction Alternative 2: Agency Reductions

Herd size could be maintained by reducing bison numbers through agency reductions. Under this alternative, agency personnel from the WGFD and the NER would be responsible for the actual removal of animals. The number, sex and ages of animals to be removed would be determined following mid-winter surveys to estimate age and sex ratios of the population.

Culled animals would be sold, donated, or used for research. Bison culled in the agency reduction in the spring of 1989 were donated to Native American tribes from Wyoming and Idaho. One animal was also donated to Western Wyoming College in Rock Springs. The donation of carcasses would not have to be restricted to Native Americans or academic institutions. Meat could also be donated to needy individuals or organizations. Recipients of donated carcasses would be responsible for processing and transporting carcasses at the time of removal.

All animals removed would be aged and general body condition would be determined at the time of harvest. Blood and tissue samples would be collected from all animals removed so that analyses of genetic variability and disease exposure could be made.

Reduction Alternative 3: Public Hunt Reduction

This alternative would continue the process used during 1989-1990 reductions. Reductions would be accomplished through the implementation of a bison hunt administered by the WGFD on NER and BTNF lands. Interested parties would apply for a license through the Wyoming Game and Fish Department, and hunters would be selected by a random computer drawing. Hunters would then be contacted when bison were available for removal. Each hunter would be accompanied by personnel from the WGFD. Agency personnel would select animals for culling to maintain desired age and sex ratios. As in Alternative 2, animals from all age classes, including calves, would be included in the reduction. Hunters would not be allowed to select their own animals. Should a hunter not want to take the animal selected by agency personnel, he/she would lose the right to take an animal. Each hunter would be responsible for harvesting, processing, and transporting his/her animal. The hunt would be held concurrent with the Refuge elk hunt in October and November, or any time during the winter.

Reduction Alternative 4: Trap and Transport to Quarantine

Under this alternative the population objective would be maintained by trapping bison on an annual basis after they have migrated to their wintering grounds. All the animals trapped would be tested for brucellosis and tuberculosis. Any animals that test positive for tuberculosis would be destroyed immediately. Animals that test positive for brucellosis would be marked with ear tags and released. Only animals that test negative for TB and brucellosis would be considered for transport to quarantine.

Current state and federal disease regulations do not permit the transport of animals that test positive for brucellosis out of the county (Wyoming State Statute 11-19-101). These regulations also state that all animals that test negative must be quarantined for a minimum of 7 months prior to transport (USDA-APHIS 1992). However, in response to a need identified by the GYIBC, the Animal and Plant Health Inspection Service (APHIS) has recently developed a draft protocol for establishing and utilizing a brucellosis quarantine facility for bison. The protocol would become part of the Brucellosis Eradication Uniform Methods and Rules (USDA-APHIS 1992). If approved and adopted by the federal government and the states involved, this would allow the immediate transport of brucellosis test-negative bison from Teton County to a quarantine facility. Animals approved for transport from the quarantine facility could be donated to other government agencies, Native American groups, or universities, or could be sold to private interests.

The draft quarantine protocol (USDA-APHIS 1995) stipulates that quarantine facilities could be located in either GTNP or YNP, or in adjoining areas of Idaho, Montana, or Wyoming. Once at the facility, bison would be held separately according to sex and age and serologically tested every 30 days. Reactors (test-positive animals) would be removed and sent to slaughter. Depending on the sex and age of individual bison, a variety of measures would be required prior to release from quarantine, including 1) repeated, consecutive negative herd tests at specified intervals, 2) for mature females, two brucellosis-free calving events in quarantine, 3) for immature male bison, annual negative tests until all animals are at least 3 years old, and 4) for immature female bison, annual negative tests until all females are bred and have a brucellosis-free calving event. Assuming that females are 3 years old at first breeding, this protocol would result in bison being held in quarantine for a minimum of 6 months for calves born in quarantine and adult males, 16 months for adult females, 16 - 48 months for immature females, and 6 - 36 months for immature males. Some individuals could be held in quarantine for much longer periods depending on test results and actual age of sexual maturity.

Available data suggest an approximate 77% seroprevalence for brucellosis in the JBH. Consequently, to meet cull objectives and obtain the desired number of animals for removal, a majority of the herd would have to be trapped and tested for disease. But since this may not always be logistically possible (due to variable movements and distribution of the herd), this alternative may need to be combined with another reduction method in some or all years to obtain a cull of the desired sex and age composition.

To capture bison for testing and for holding prior to transport, a temporary trapping and handling facility would be built on the winter range. The facility would include drift fences to guide bison into capture and holding pens. The drift fences would be supported by a series of 7-foot-long wooden posts (4-inch minimum diameter) and steel-t posts spaced 20 feet apart (1 wooden post for every 4 steel posts). A 3-foot-high, 12.5 gauge, high-tensile mesh wire fence would be placed 2 feet above the ground for a fence height of 5 feet. The fences could be constructed so that they could be taken down from the support posts when capture operations are not being conducted.

Holding pens would be constructed of 7-foot-high, 12.5 gauge high-tensile mesh wire supported by 10-foot-high, 6-inch diameter wooden posts and 10-foot-high steel-t posts. A single, offset, solar-operated, electrified wire would be placed around the inside perimeter of the capture and holding pastures. Capture and holding pens could enclose several acres.

The pens would be connected to a handling facility consisting of up to 3 temporary 7-foot-high steel-pipe holding corrals, a crowding tub, alleys, and a squeeze chute. Alleys, squeeze chute, and corrals would require special-order, heavy-duty materials designed specifically for holding bison. The handling facility would probably be larger than 10,000 square feet.

U.S. Fish and Wildlife Service policy states that bison will be fenced at no refuges besides those four established by Congress early in this century for the perpetuation of bison herds (see INTRODUCTION, Agency Policies and Mandates). If the NER is determined to be the most appropriate location for a trapping facility, however, securing an exemption from the Service's policy would be pursued.

Reduction Alternative 5: Native American Hunt Reduction

This alternative would be similar to Alternative 3 except that only peoples from bona fide Native American tribes would be allowed to harvest bison. This alternative recognizes the cultural significance bison have for many Native Americans. Historically, before their near extirpation in the late 1800s, bison were central to the lives and cultures of many of the native peoples of North America. Bison provided food, clothing, shelter, tools, and other material needs, and tribes' patterns of living were intimately linked with bison. Besides providing physical subsistence, bison were a central element of many tribes' philosophy and religion. Despite the loss of most of the continent's free-ranging bison and the native ways of life associated with them, many tribes today maintain a deep spiritual and cultural connection to bison (Callenbach 1995, Ravndal 1996). Many native people refer to bison as the "buffalo nation," acknowledging bison as relatives and according them great respect (Intertribal Bison Cooperative 1996).

The present-day tribal lands and historical hunting grounds of the Shoshone-Bannock, Eastern Shoshone, Northern Arapahoe, and Crow tribes fall partially within the GYA. Numerous other tribes have historical connections with both bison and the GYA (Ravndahl 1996). Many tribes have a strong interest in obtaining bison for food and for ceremonial uses.
Native American tribes would be contacted when bison are available for harvest. Agency personnel would accompany tribal members and select which animals would be culled. Tribal members would be responsible for harvesting, processing, and transporting the animals. Most culling would probably occur during winter when bison are on wintering grounds and are easily accessible.

Reduction Alternative 6: Trap, Test, and Slaughter

This alternative would be similar to Alternative 4 except that animals would not be transported out of the herd unit alive. Once animals were trapped, they would be tested for brucellosis and tuberculosis. Animals that test positive would be destroyed until enough animals were removed to keep the herd at the recommended population objective. The carcasses could be donated to Native American tribes, other organizations, or individuals. Carcasses could also be sold to offset management costs.

Reduction Alternative 7: Combination Public Hunt / Herd Reduction for Native American Use (PREFERRED ALTERNATIVE)

This alternative would include provisions for public hunting and use of surplus bison by Native Americans. A public hunt administered by WGFD would be held annually with a small number (5-10, depending on herd size) of hunting licenses being issued to both Wyoming residents and non-residents. All licenses issued would be for "any bison," indicating any sex and age animal could be taken. Bison hunts would occur during elk hunting seasons on the NER and adjacent BTNF lands in Wyoming elk hunt areas 77 and 80. During this period, prior to elk supplemental feeding, bison are typically scattered throughout these areas subsisting on natural vegetation. Bison hunts could also occur on other National Forest lands when necessary, but numbers taken would probably be small. The hunts would be conducted under "fair chase" principles: hunters would be on their own to find and harvest bison, and then retrieve and process the carcasses. Hunters may be required to collect biological samples (e.g. blood samples) as a condition of the permit.

The remainder of bison to be removed from the herd each year would be made available to Native Americans. Native American tribes would be contacted when bison are available. Agency personnel would accompany tribal members and select which animals would be culled. Tribal members would be responsible for processing and transporting the animals. Most culling would probably occur during winter when bison are on wintering grounds and are easily accessible.

Providing a small number of permits for a fair-chase public hunt enables agencies to offer recreational opportunities by issuing "any bison" permits, without risk of overharvesting a particular age or sex class. Agency determination of the age and sex composition of bison to be culled for Native American use will maximize genetic integrity of the remaining herd. Culling during winter, after both bison and elk are concentrated near NER supplemental feedgrounds, has several advantages: 1) accurate size and composition of the herd can be predetermined; 2) the potential for disrupting the distribution of elk wintering on the refuge will be minimized; and 3) the processing and removal of bison carcasses will be facilitated.

MANAGEMENT ISSUE III: WINTER DISTRIBUTION ALTERNATIVES

Since 1975, the majority of the JBH has wintered on the NER, and the bison have consistently used supplemental feed since 1980. From winter 1991-92 to winter 1995-96, aerial flights and ground observations showed that 149-252 bison (97-100%) in the herd wintered on the NER, and from 0-6 were observed off the NER during those winters. All bison that wintered off the NER were adult males.

During the period when elk are provided supplemental feed, bison are also fed, at high rates, to separate them from elk and to minimize their impact on elk feeding operations. Only 0-4 bison wintering on the NER each year from 1991-92 to 1995-96 did not eat supplemental feed.

The habituation of bison to supplemental feed on the NER has created a number of problems. Commingling of the species during feeding creates an opportunity for transmission of brucellosis between elk and bison. In modelling the effects of brucellosis on growth of the JBH, Peterson et al. (1991) predicted that the most likely year of brucellosis infection was 1980, the year the JBH first began eating supplemental feed intended for elk. The concentration of animals that occurs during feeding also increases the potential for intraspecific transmission of brucellosis among bison. The feeding of bison is costly and contrary to the managing agencies' goals of having a free-roaming bison herd that is not dependent on supplemental feed. If bison ate only standing forage on the NER and did not consume supplemental feed, most adverse consequences of their presence on the Refuge would be diminished. It is unrealistic, however, to expect bison to discontinue their use of supplemental feed as long as they occupy the Refuge.

Significant reductions in the supplemental feeding of elk are not likely until numbers of elk that winter on the NER are nearer carrying capacity of the winter range. Efforts to reduce the Jackson elk herd, and specifically the number of elk wintering on the NER, will eventually diminish the need to feed elk in winter. Reducing elk numbers is hampered by the difficulty of adequately harvesting elk that summer in GTNP (and winter on the NER), without excessively harvesting elk that summer on National Forest lands (Smith 1994, Smith and Robbins 1994). Seasons designed to harvest more female elk in GTNP and the NER, and allowing hunters to harvest more than one antlerless elk on the NER beginning in 1997, should help reduce elk numbers in time.

Recognizing the drawbacks of the current winter situation, the following alternatives were developed in an effort to analyze other management options for wintering the JBH. In addition, to allow for the development of a full range of alternatives, current agency practices, policies, and other constraints were not viewed as absolute barriers. They were considered, however, in the analyses of the alternatives.

Alternatives Considered But Rejected:

1. Fencing bison out of the NER, thereby forcing them to use native winter range in other areas, was considered. Keeping bison out of the NER would require a minimum of 8.5 miles of fence along the Gros Ventre River. There are no known fence designs, however, that will selectively exclude bison but not elk, moose, deer, and pronghorn. Jackson bison also readily cross cattle guards. Any fence effective in prohibiting the movement of bison onto the NER would also prohibit the movement of elk and other species, which would result in unacceptable impacts.

Bison-proof drift fences, to steer bison away from the NER, would probably prove ineffective. Along Yellowstone National Park's northern boundary, drift fences were constructed but failed to deter bison from leaving the Park (Meagher 1989a). Likewise, hazing has proven futile in restricting movements of bison on more than a temporary basis. Bison either become conditioned to hazing, bypass locations, or avoid the times when it occurs (Meagher 1989a, 1989b). Efforts to haze bison away from supplemental feed on the NER have met with little success, and only persistent and repeated hazing keeps them away from roadways and residential inholdings.

Furthermore, denied access to the NER, bison would likely wander into new areas during winter and spring. These may include State elk feedgrounds in the Gros Ventre drainage or south of Jackson, or private lands. Consequences could include increased risk of disease transmission to livestock and economic impacts on land jurisdictions where the bison do not currently spend time. Consequently, this alternative was rejected from further analysis.

2. Discontinuing supplemental feeding of elk on the NER was considered. Winter feeding of both elk and bison artificially concentrates both species on the NER and is responsible for

maintaining brucellosis in both species in western Wyoming (Thorne et al. 1991a, 1991b). Discontinuing the NER feeding program would permit bison, elk, and other large herbivores to commingle on the Refuge and to forage across Refuge and adjacent winter range.

This alternative would probably result in a smaller elk herd as mortality increases in severe winters. Since 1911, the Jackson elk herd has been maintained at a population size that exceeds available winter habitat by supplementing their diet with alfalfa hay in all but the mildest of winters (Robbins et al. 1982). The number of elk that the NER could support on a sustained basis is 50%, or possibly less, of the 10,000 that wintered there in 1995-96. Bison numbers might increase relative to numbers of elk, given the bison's greater foraging efficiency in deep snow. Populations of both species would fluctuate to a greater degree than they do now because diminishing food resources would not be mitigated by food supplementation.

Several significant adverse impacts of discontinuing winter feeding would be likely. First, elk and/or bison would be likely to disperse from the NER onto adjacent lands when food resources become depleted in a winter of average or above average severity. Some or many of these animals would be likely to venture onto private lands south and west of the Refuge (where cattle herds are wintered), onto heavily travelled roadways, and into the town of Jackson. Limited numbers of elk do so even now, and are hazed back onto the Refuge where they generally remain when winter feeding begins. Dispersal of elk and bison onto roadways and private lands would create highway safety concerns and increase the probability of brucellosis transmission to cattle with which elk and bison might commingle on livestock feedgrounds. Finally, the probable reduced size of the Jackson elk herd would have extensive ecological, social, economic, and political consequences that are beyond the scope of this document to address. These consequences would affect the local and regional environment and be significant at the state and national level. Consequently, this alternative was rejected from further analysis.

Winter Distribution Alternative 1: No Action

Under this alternative, bison would be permitted to continue wintering on the NER as they have since 1975. Bison would continue to move onto the NER during late summer or fall at their choosing and use standing forage during the 7-8 months they remain on the Refuge. During the period when elk receive supplemental feed, bison would also be fed at rates of approximately 22 lbs/bison/day, or about $120 per winter for each bison in the herd. These high feeding rates would be necessary to ensure adequate spatial separation of bison from elk during feeding operations, thus ensuring that elk receive their prescribed daily ration. Hazing of bison away from visitor facilities, public roads, and the town of Jackson would continue. Hazing would also continue each spring to persuade bison to leave the NER, and to discourage year-round residency on the NER.

Winter Distribution Alternatives 2 - 5: Background Information

Each fall during September and October, all or a majority of the bison herd congregate on the haylands of the Hunter-Talbot area in GTNP. Here they generally forage on the grasses of the haylands and adjacent lands for several weeks until they migrate to the NER. Prior to 1992 they appeared to be attracted to the area because of the irrigated (green) forage. Bison use seemed to decline in 1992 when irrigation was discontinued, but the Hunter-Talbot area is still consistently used by large numbers each year. Generally, bison use the area again in spring as they migrate north. Although this area receives winter and spring use by moose, which are primarily browsers, little use occurs by elk or other big game that may compete with bison. Thus it offers winter range for bison away from NER feedlines. During the winters of 1973-74, 1974-75, and 1976-77 many of the bison wintered in this area and the adjacent Mormon Row-Kelly Hayfields area (USDI-NPS 1986) and none wintered on the NER. Consequently, this area served as a focal point for the formulation of the winter distribution alternatives that follow.

An important factor in bison choice of wintering ranges is snow depth and consistency. Whether potential winter range will be used is dependent on bison behavior and the vagaries of each winter's snowfall pattern. Ongoing research being conducted by GTNP will use snow depths and water equivalents measurements to model potential bison and other ungulate winter range in Jackson Hole. Completion of this research in late 1997 will allow wildlife managers to better identify potential bison winter range.

<u>History and Location of the Hunter-Talbot</u>

The Hunter-Talbot area consists of two formerly privately owned and operated cattle ranches within the congressionally established boundaries of GTNP. Both ranches are now under federal ownership and are administered by the National Park Service. The two ranches--the 160-acre Hunter Ranch and the 170-acre Talbot Ranch (or Aspen Ridge Ranch)--share a common boundary and are situated along the east side of GTNP, 3 miles north of the NER and adjacent to the BTNF. This area is accessed by a paved road that is closed to the public. This part of the Park receives very little public use, is not visible from either of the Park's 2 major roads, and is distant from any of the Park's primary facilities or attractions.

<u>Description and Facilities</u>

Approximately 230 acres of formerly irrigated hayland exists in the immediate area. These are disturbed grounds seeded to tame grasses (primarily smooth brome) and alfalfa for pasturage and hay production and formerly irrigated by flood irrigation from ditches drawing water from Ditch Creek. An additional 100 acres of dryland farmed tame grasses were also hayed. Prior to 1979, the hayland produced about 3 tons/acre of hay which was mowed and put up for winter feed. There are hay and equipment storage sheds and electrical power to the area.

Present Use

In 1979, a special use permit was issued to the Triangle X Dude Ranch permitting them to irrigate the haylands, mow and put up hay, and to winter and feed up to 160 horses in the area. Their permit was subject to annual review and renewal, and in 1986 the permittee was given notice that the special use permit would be terminated at the end of 1991. The Triangle X wintered and fed up to 130 horses each winter from 1979 - 1991 on the Hunter-Talbot area. The dates of use in the special use permit allowed horse pasturing from mid-November to mid-April each year. In recent years, hay production had declined to less than 1.5 tons/acre. No irrigation, haying, or livestock grazing has taken place at the Hunter-Talbot since 1991. The National Park Service's intention for these lands was to allow them to revert to native vegetation after termination of the special use permit.

During August 1994, approximately 2,300 acres of sagebrush-grassland and the Hunter-Talbot haylands were burned by a wildlfire that began just north of the Antelope Flats Road. Water control structures of the haylands' irrigation system were also burned in the fire. In 1995, as many as 175 of the Jackson bison herd used the burned area during summer and fall until the first week of December when all the bison had migrated to the NER. Forage utilization rates were measured during spring 1996 and measurements will be continued to determine forage use in the burn compared to adjacent unburned areas.

Three alternatives for wintering bison in the Hunter-Talbot area away from NER feedlines are discussed below. These alternatives differ in the techniques by which the herd's habit of migrating to the NER would be altered. The abundant forage of the Hunter-Talbot fields would constitute the primary food source for the bison. To enhance success of each alternative and to obtain the greatest value from these fields, the irrigation system would be renovated and the grass/alfalfa crop would be irrigated during summer and fall. Jackson bison seek out areas of nutritious green forage during late summer and fall, as evidenced by their attraction to the Hunter-Talbot fields when those were irrigated and by their movements and distribution on the NER each fall. Ditch Creek provides a source of water for the bison. Providing supplemental feed may play a role in Alternatives 2 and 3 depending upon desired herd size and bison behavior.

As part of both Alternatives 3 and 4, additional area on the BTNF, adjacent to the Hunter-Talbot in GTNP, would be included as designated bison range. Bison would be encouraged to use this area during fall, winter, and spring as they have in the past, snow depths permitting. Herd reductions would not take place there. This area is defined as: beginning at the common corner of sections 10, 11, 14, and 15 (T43N, R115W); proceeding south and east along the GTNP boundary to the Gros Ventre Road; east along the Gros Ventre road to the east section line of section 6 (T42N, R114W); north along section line to common corner of sections 7, 8, 17, and 18 (T43N, R114W); and west along section line to point of beginning (Fig. 2).

Winter Distribution Alternative 2: Fence Bison at the Hunter-Talbot Area During Winter

Under this alternative, bison would be baited and/or herded into a 330-acre fenced enclosure in the Hunter-Talbot area where they would spend the winter subsisting on standing forage and supplemental feed if necessary. The need for supplemental feed would depend largely on the size of the herd. The enclosure would include 230 irrigated acres and 100 acres of unirrigated grassland and sagebrush adjacent to the Hunter-Talbot (Figure 2).

Estimates of carrying capacity in the Hunter-Talbot area vary according to the intensity of management (Appendix V). If summer irrigation were resumed on the 230 acres of irrigated hayland and all forage was left standing, an estimated 100 bison may be sustained in the enclosure with no supplemental feeding for 8 months (September-April). A larger herd would require purchasing additional hay or cutting hay on site to feed the bison during part of the winter. If one cutting of hay was taken from the 230 irrigated acres for winter feed, enough forage may be available to sustain 163 bison for 8 months without purchasing additional feed (see Appendix V for a complete explanation of how carrying capacity estimates were derived).

In either case, continued irrigation would be required. Since this area once produced nearly 3 tons of hay/acre, intensive farming and irrigation practices may preclude the need for cutting hay, even with larger herd sizes. If the herd size necessitated cutting hay, the farming and haying would be contracted. Surplus hay produced in any year could be left uncut, or cut and stored for supplemental feeding the following year.
Hay and equipment storage facilities are available in the area and would be used as necessary. Feeding would be done 1) by a team and sled, as on the State of Wyoming's elk feedgrounds, 2) by snowmobile-drawn sled, or 3) with a small Caterpillar crawler tractor and feed trailer. It is anticipated that existing agency equipment could be used.

Enclosing the 330 acres in the Hunter-Talbot area would require about 3 miles of fencing. Fencing would consist of either 1) a 7-foot high, 11-gauge net wire fence supported by wood posts with a 12-foot spacing (such as that used on the National Bison Range in Montana), or 2) a 6.5-foot high, 11 wire, high-tensile electric fence.
The success of this alternative in controlling winter distribution of bison depends on the enclosure being bison-proof. Bison are easiest to hold behind fences if they are born there or translocated to fenced pastures as calves. Adult animals, not accustomed to confinement, are much more likely to break through fences, and may injure themselves or other bison in the process. How bison from the JBH would react to being fenced is unknown.

Winter Distribution Alternative 3: Feed Bison At The Hunter-Talbot Without Fencing

This alternative would be identical to Alternative 2 except that bison would not be fenced into an enclosure. Feeding a maintenance ration of long or pelleted hay would be relied upon to hold the bison in the Hunter-Talbot area. It is uncertain whether feeding hay would deter bison from moving onto the NER. In some years, bison begin arriving at NER as early as September. It may therefore be necessary to begin feeding bison during the fall, at least on a small scale, to hold them in GTNP. If the bison moved onto the NER and used supplemental feed provided to elk, there would be little recourse but to allow them to remain there for the remainder of the winter. Since bison are extremely difficult to haze and generally do not respond to such tactics (Meagher 1989a), hazing would not be attempted under this alternative. Bison migrating to the NER would be candidates for removal to meet population objectives (see Herd Reduction Alternatives).

Winter Distribution Alternative 4: Modify Bison Behavior and Winter Distribution Through Baiting at the Hunter-Talbot (PREFERRED ALTERNATIVE)

This alternative is considered experimental. Managers would attempt to hold the bison in the Hunter-Talbot area during the winter by baiting them with a highly desirable food, such as pellets comprised of grains, hay, and molasses. In other areas, such as private ranches and the Sully's Hill National Wildlife Refuge, bison have demonstrated a clear craving for certain foods. These foods have been effectively used to manipulate bison distributions and movements, as well as to bait them for capture (S. Kresl, Sully's Hill National Wildlife Refuge, pers. comm. 1991). Rather than feeding bison a maintenance ration of supplemental feed, baiting would serve only to hold and habituate bison to a new wintering area (the Hunter-Talbot area) over time. Standing natural and irrigated forage in the immediate area would provide the bulk of their diet. Irrigation of the 230 acres of haylands that were irrigated prior to 1991 on the Hunter-Talbot would be resumed under this alternative. Irrigated pastures would be left as standing forage for use by bison; hay would not be cut. If after several years this technique is successful at modifying bison migratory behavior and distributions, baiting would gradually be phased out.

Initially, baiting daily or even twice per day may be necessary to "hook" the bison on the chosen bait. After the first year or two, less frequent baiting may be required to habituate the bison to the area during winter. The chosen bait would be stored in existing facilities at the Hunter-Talbot area and provided to the bison from some time in fall through winter.

The goal of this alternative is to winter bison in GTNP and on adjacent National Forest lands. An increasing trend in numbers of bison remaining in these and other areas away from NER feedlines would provide evidence that continued pursuit of this alternative is warranted. If progress toward these goals is not evident 5 years after implementation of this management plan, changing wintering areas of the JBH will be reevaluated. Further evaluation will occur at a maximum of 5-year intervals. Annual winter severity, productivity of the irrigated Hunter-Talbot fields, attraction of bison to bait, individual bison behavior (particularly of adult females), and numerous other unpredictable variables will influence the outcome of this alternative.

This alternative will not establish a permanent feeding station within GTNP. It is an experimental attempt to change bison migratory behavior and winter distributions. The long-term goal is to restore an unfed, free-ranging bison herd to Jackson Hole. If successful, bison would remain in the Hunter-Talbot area throughout relatively open (snow-free) winters.

In more severe winters, part of the JBH will probably wander onto the NER. The number of bison that are allowed to winter on NER feedlines will depend on the selected Herd Size Alternative. For example, under the Preferred Alternative (Alternative 3), if baiting does not keep all the bison away from the feedgrounds, up to 200 bison would be allowed on NER feedgrounds before population reductions were initiated. The sliding scale described under Herd Size Alternative 3 and in Table 2 would be used to determine reduction levels. Removal of bison that winter on elk feedlines could in time help select for a bison herd that uses predominantly free-standing forage.

Carrying Capacity of Winter Range. Several carrying capacity estimates were made to determine the number of bison that the greater Hunter-Talbot and Mormon Row-Kelly Hayfields areas could support. The Hunter-Talbot area comprises 330 acres of previously cultivated fields to the north of Ditch Creek in GTNP. This includes the 230 acres proposed for irrigation and haying under Winter Distribution Alternatives 2 and 3, and 100 acres of non-irrigated land. The greater Hunter-Talbot area includes the Hunter-Talbot plus another 1,088 acres to the south of Hunter-Talbot in Sections 23 and 26. The Mormon Row-Kelly Hayfields area includes 3,776 acres of land bounded by the Mormon Row, Antelope Flats, Shadow Mountain, and Kelly roads (Fig. 2). Appendices V and VI show the acreage and forage production of each area. These are areas previously used by bison in winter and currently used, to some degree, by bison during spring and fall. Estimated carrying capacity of the greater Hunter-Talbot area is 118 bison for 8 months (September-April), if forage utilization equals observed rates at the NER (Appendix VI). Because baiting would be phased out once bison become habituated to wintering in GTNP, baiting should not be considered a long-term source of nutrition for the JBH and was not used as a basis for carrying capacity estimates.

Although baiting may concentrate bison activity in the Hunter-Talbot area, some foraging could be expected further west in the Mormon Row-Kelly Hayfields area. Bison sporadically graze this area during both fall and spring. During winter 1976-77, all 15-20 animals in the herd wintered in the Mormon Row area and to the east. The previously cultivated fields in this area have remained largely non-irrigated for 25 years, and 60% of the area consists of dense stands of big sagebrush which have reduced the productivity of herbaceous biomass. Because snow accumulates to greater depths on the Hayfields than on much of the NER, an average forage utilization rate of 10% of graminoid vegetation (which is typical of the higher elevations and deeper snow areas on the NER) was estimated. Using this estimate, Mormon Row-Kelly Hayfields could support an additional 91 bison for 8 months (Appendix VI). Thus it appears that between the greater Hunter-Talbot and the Mormon Row-Kelly Hayfields areas, there is enough forage to support about 209 bison.

The predictive ability of these estimates of carrying capacity in the Hunter-Talbot and Mormon Row-Kelly Hayfields areas depends on the willingness of bison to remain in the area as snow depths increase during winter. Information obtained from ongoing work to model snow depths and water equivalents will enhance management agencies' ability to define potential bison winter range in the future.

Because the JBH has migrated to the NER for 20 winters, providing palatable bait and irrigating the 230 acres of haylands at the Hunter-Talbot will be fundamental strategies to alter the herd's behavior. Restoration of historic fire cycles in the Mormon Row-Kelly Hayfields area would help to provide attractive foraging areas to bison and other wildlife. Fire return cycles are estimated at 30 years in the sagebrush community of GTNP (Len Dems, GTNP, pers. comm. 1996). Frequent small prescribed burns are planned to be used to mimic natural fire cycles. Bison would be attracted to such burns, as indicated by their response in 1995 and 1996 to the area burned in the 1994 Row Fire.

Additional Winter Range. Since winter 1976-77, all but 2-8 members of the JBH have wintered on the NER. Bison that wintered off the NER were all adult males who primarily used the Snake River riparian corridor, Uhl Hill-Wolf Ridge, and the Hunter-Talbot vicinity during winter. When foraging conditions remain favorable during all or part of the winter (e.g. light snow and readily available forage), limited numbers of bison will continue to use those areas. We cannot predict if greater numbers may use those or pioneer additional winter ranges, as a larger proportion of the JBH remains north of the NER in winter.
Under favorable winter conditions, 50 animals at most may remain in areas other than the Hunter-Talbot and Mormon Row-Kelly Hayfields areas (and not on the Refuge near elk feedgrounds). Because of the increasing snow depths on the mountain slopes, the designated bison range east of GTNP and the south facing slopes of Ditch Creek north of the Teton Science School (Fig. 2) are expected to sustain only 10-15 bison in average to mild winters. Although bison have used National Forest lands east of the NER in fall and early winter, they do not remain there once supplemental feeding of elk begins. For example, during winter 1995-96, up to 10 bison used National Forest lands east of the NER. All 252 bison on or adjacent to the NER, however, were at NER feedgrounds within 7 days after feeding of elk was initiated.

Forage available to bison in most winters may support an estimated 5 bison in the Snake River riparian corridor and perhaps 10 or more in the Wolf Ridge-Uhl Hill area. Bison are unlikely to winter in these areas, however, until the herd becomes accustomed to wintering away from NER feedlines and after baiting in GTNP ceases. Even then, traditional migration behavior, the irrigated haylands at the Hunter-Talbot, and any lingering attraction of supplemental feed on the NER are likely to limit the number of bison that winter farther north or west than the Antelope Flats Road. Should female-subadult groups choose to winter in some of these potential additional winter ranges, it will hasten the successful transition of the JBH from a population that is supplementally fed on the NER to a free-ranging herd that subsists on standing forage in winter.

Winter Distribution Alternative 5: Fence Bison at the National Elk Refuge During Winter

Under this alternative, bison would be seasonally confined to a fenced enclosure on the NER during winter and spring. They may or may not be supplementally fed depending upon herd size, availability of standing forage within the enclosure, and size of the enclosure. Bison would free-range throughout the remainder of the year. This would limit commingling of bison with elk, and thereby reduce competition for food and the potential for disease transmission. Under this scenario, a site on the north end of the NER along the traditional migratory route of the bison would be fenced with a 7-foot high, 11-gauge net wire fence supported by wood posts with a 12-foot spacing. Bison would be baited and herded into the enclosure during fall after they arrive on the Refuge. Herbaceous forage production on the northern portion of the Refuge averages 650 pounds/acre (0.33 tons/acre). To maintain 200 bison, assuming 20 pounds/animal/day for 6 months and a proper use factor of 50%, about 2,200 acres would have to be fenced. If a double fence were deemed necessary to minimize contact between bison and elk in order to reduce opportunity for disease transmission, costs would double. Feeding bison within the enclosure would reduce the required size of the enclosure, but would increase recurring annual costs for maintenance of the herd as well as the potential for habitat degradation.

Like Alternative 2, the success of this alternative in controlling winter distribution of bison is predicated on an enclosure being bison-proof. Bison are easiest to hold behind fences if they are born there or translocated to fenced pastures as calves. Adult animals, not accustomed to confinement, are much more likely to break through fences, and may injure themselves or other bison in the process. How bison from the JBH would react to being fenced is unknown.

MANAGEMENT ISSUE IV: DISEASE MANAGEMENT ALTERNATIVES

Infectious disease is a concern in the management of the JBH because of potential transmission to domestic animals (primarily cattle). Brucellosis, which is known to occur in the JBH, is ecologically unimportant; bison herds are generally able to grow and maintain themselves despite the disease. On the other hand, tuberculosis, which has not been found in the JBH but has been identified in bison in Wood Buffalo National Park in Canada and elsewhere and in game-farmed elk, could have substantial impacts on the herd.

Tuberculosis

Tuberculosis is an infectious disease of most warm-blooded vertebrates. A variety of species of bacteria in the genus Mycobacterium cause tuberculosis. The most prevalent in cattle and bison is Mycobacterium bovis. The primary mode of transmission is through ingestion or inhalation of the bacteria shed from infected animals in feces and respiratory secretions. The disease is generally characterized by slow, progressive development of tubercles (firm nodules) in any organ and is usually fatal. The most common sites for tuberculosis include respiratory and gastrointestinal tracts and lymph nodes. General signs of infection include progressive emaciation, sluggishness, and a fluctuating temperature. Disease in the respiratory tract is characterized by a chronic moist cough.

Tuberculosis is significant because of its ability to infect wildlife, domestic livestock, and humans, and because the disease is generally fatal in animals. Tuberculosis has been confirmed in at least 13 game farm (confined) elk herds in the United States, including Montana (4), Nebraska (1), Colorado (1), New York (3), Oklahoma (1), Texas (1), Idaho (1), and Wisconsin (1) (Essey and Meyer 1992). Tuberculosis-infected mule deer and coyotes have been found during surveillance activities outside an infected game farm in Montana (Aune 1995). Elk from United States game farms have been identified as the source for infected elk in Canada (Pybus 1993) where an estimated 3000 elk have been under quarantine. Bison are quite sensitive to the disease. Tuberculosis has national significance and is the current target of an eradication program conducted by USDA and state agriculture agencies. The bacterium that affects wildlife is also highly pathogenic to people and can be transmitted through infected animals, tissues, or other animal products such as milk. At this time the disease is not known to occur in the Jackson bison or elk herds. Consequently, tuberculosis will not be discussed in the evaluation of alternatives.

Brucellosis

Brucellosis in bison, elk and cattle is caused by the bacterium Brucella abortus. The disease is generally characterized by abortion in late pregnancy and subsequent variable rates of infertility (see Appendix VII for a complete discussion of the bacterium and its effects). Some bison from the JBH are known to be brucellosis infected, and the current seroprevalence (i.e. animals that test positive for Brucella antibodies but may or may not have the disease) is approximately 77% (see Appendix VIII). The true infection rate is unknown, but the tissue culture isolation rate for seroreactors was 36% (Williams et al. 1993). The JBH currently winters on the NER with 7,000-10,000 elk. Brucellosis seroprevalence among the adult female elk is 39% (Oldemeyer et al. 1993). The true infection rate for elk is unknown, but Thorne et al. (1978) isolated Brucella abortus from 17 of 45 (38%) seropositive elk from feedgrounds in western Wyoming. The states of Wyoming, Montana and Idaho are classified by APHIS as free of bovine brucellosis. Brucella abortus infection can also occur in humans (where it is more commonly known as undulant fever), but its presence in wildlife does not represent a significant human health hazard. The disease in humans is discussed in Appendix VII.

Brucellosis Diagnosis

Diagnosis of brucellosis is complicated and uses two methodologies. The primary method is serological, which relies on detection of antibodies in serum. Individuals that show the presence of antibodies may or may not have the disease. Antibodies to brucellosis may persist after the infecting agent has left the host. The second method of diagnosis confirms presence of the bacteria through isolation of the organism. See Appendix VII for a complete discussion of diagnostic methods.

Brucellosis in Bison and Elk

The primary significance of brucellosis in wildlife is the potential for transmission of the disease to domestic cattle. Brucellosis has been estimated to have cost the cattle industry $1.6 billion from 1951 to 1981 (Thorne et al. 1991). The federal contribution to the current brucellosis eradication program exceeds $60 million per year. The goal of the program is to eliminate the disease from domestic livestock in the United States. To achieve this goal APHIS favors elimination of the disease from wild animal species, but no realistic means of accomplishing this, short of depopulation of elk and bison from the GYE, have been proposed (Boyce 1995). The Veterinary Services office of APHIS administers the brucellosis eradication program nationwide but has no authority over free-ranging wildlife (Keiter and Froelicher 1993). Eradication of the disease, if such could be accomplished, would eliminate direct costs of the disease and the costs associated with an ongoing eradication program, and would minimize the costs associated with a monitoring program.

The first serologic evidence of brucellosis in bison was from Yellowstone National Park in 1917 (Mohler 1917 cited in Davis 1990a), and the bacterium was first isolated in Montana bison in 1930 (Creech 1930). Testing of 2,211 sera from Yellowstone National Park bison (1965-1985) yielded a seroprevalence rate of 37% (817 positive samples) (Clark and Kopec 1985).

Prior to their escape from the enclosed Jackson Hole Wildlife Park in 1968, the 15 animals in the JBH had been tested and were believed to be free of brucellosis (GTNP files). Three possibilities exist for the source of the JBH's current brucellosis infection: 1) undiagnosed brucellosis carrier calves may have been left in the herd; 2) because of the potential for false negative tests, the herd may not have been free of brucellosis when released; or 3) the bison may have been infected by elk on the NER. The current seropositive rate in the herd, based on samples from 35 animals collected between 1989 and 1990, is approximately 77%. Males appear to have higher seropositive rates (84%) than females (69%).

Some elk in the greater Yellowstone area are also infected with brucellosis. Serologic evidence of brucellosis in elk from Yellowstone National Park was first presented in 1932 (Rush 1932) and prevalence rates (based on testing procedures that were used at the time) were low (19%) compared to bison (Tunnicliff and Marsh 1935). Rush (1932) found a seroprevalence rate in bison of 75%. The most recent data from elk taken in Yellowstone National Park are from the 1960s herd reductions. These unpublished data show a seroprevalence of only 1.7% (M. Meagher, Yellowstone National Park, pers. comm. 1990). Similar seroprevalence rates have been shown in elk near Yellowstone National Park in Montana (Rhyan et al. in press).

High seroprevalence rates in Wyoming elk are a direct result of herds using winter feedgrounds. Thorne et al. (1978) reported 31% seropositive elk out of 1,165 samples from Wyoming feedground elk and isolated the bacteria from 17 of 45 elk. Seropositivity in female elk from the NER, which commingle with JBH bison during the winter, has averaged 39% (Boyce 1989). The opportunity for bison and elk to transmit disease organisms is greatest in feedground situations due to the artificial concentration of animals (Thorne et al. 1979, Smith and Roffe 1994). Thorne et al. (1991) detected brucellosis seroprevalence in elk (x= 37%) at all 18 State of Wyoming feedgrounds where elk have been blood tested. In non-feedground situations in Wyoming, testing over the last 6 years indicates an average seroprevalence of less than 2% (n=50/2792). Data from non-fed elk populations outside the Greater Yellowstone Area in Colorado, Montana, Idaho, California, and Wyoming show no evidence of brucellosis infection.

The impacts of brucellosis on wildlife are difficult to assess. In experiments where bison were challenged (i.e. purposely infected with a laboratory strain of brucellosis), 96% aborted (Davis et al. 1991). Essentially, this represents every infected animal losing one calf. Abortion rates in naturally infected bison are unknown. Thorne (1978) estimated the abortion rate in naturally infected elk at approximately 50% of first pregnancies following infection and stated that a much smaller percentage of cows experience reproductive failure during subsequent pregnancies (Thorne 1982a). If each female elk is assumed to produce 6 calves over an average 8-year lifetime (B. Smith, T. Toman, pers. comm.. 1993) and if each cow has a 50% probability of losing her first calf, then the herd's potential reproduction would be reduced by 8%. Work conducted on the NER (Oldemeyer et al. 1993) estimated that brucellosis-infected elk have a 13% decline in reproductive success compared to non-infected elk. Extrapolating these data to the entire herd (39% brucellosis prevalence in females), yearly herd reproductive success would be about 7% less than theoretically expected (Oldemeyer et al. 1993). Some cows abort a second time, although this is considered rare. In summary, although some decrease in reproductive potential probably occurs, neither bison nor elk have demonstrated any long-term reproductive declines. In fact, populations of both species have increased dramatically during the last 25 years.

Transmission

The mechanism of transmission of brucellosis in bison is a source of debate and current research (see Appendix VII for a discussion of this issue). Based on cattle data and limited elk and bison data, the major sources of infection and contamination of grounds and feed are aborted, brucellosis-infected fetuses and fetal membranes. These tissues contain very high numbers of Brucella organisms which can be transmitted by ingestion, penetration of the skin or conjunctiva (eyelid), or contamination of the mammary gland. Ingestion, through contact with infective tissues, grazing on contaminated pastures, and consuming contaminated feed or water, is considered the most important means of spreading the disease (Crawford et al. 1990).

Infected bovine bulls rarely transmit brucellosis via semen to cows and are not considered important in the epidemiology of brucellosis in cattle. The available data on the role of bull bison in brucellosis transmission are limited but suggest they are unimportant (GYIBC 1996). Most infected calves are aborted, stillborn, or are born weak and die. In cases where the calf survives, congenital infections can occur. As many as 20% of surviving heifers born to infected cattle may remain persistently infected (Crawford et al. 1990).

Transmission between species depends on the prevalence of disease in the population, frequency of shedding infected birth products, persistence in the environment of shed Brucella organisms, and the social behavior of the species involved. Cattle may shed infective doses through reproductive tissue and fluids up to 30 days following abortion (Rinehart 1991). In temperate climates the Brucella organism has been reported to survive for up to 180 days in direct sunlight during winter, 30 days in summer in the environment if kept moist (Blood et al. 1979), and over 8 months in manure (Plommet 1972). Freezing permits almost indefinite survival of the bacteria.

The social structure of bison and cattle is conducive to the spread and/or maintenance of brucellosis infections. Cattle are gregarious and prefer to calve in the presence of other cattle. Bison are also gregarious and may calve in the presence of other bison or isolate themselves only briefly. In contrast, elk under free-ranging conditions are more widely distributed during the later stages of pregnancy (winter season), and elk cows usually seek seclusion when calving (Geist 1982). Both behaviors minimize the chance for the spread of brucellosis, and the disease does not appear to be able to maintain itself at significant levels in free-ranging elk populations.

On elk winter feedgrounds, however, artificially high densities of elk are maintained during the time of highest likelihood of abortion. In Wyoming, approximately 24,000 elk are fed at 23 feedgrounds, including the NER. Brucellosis occurs at all 18 feedgrounds tested to date and is assumed to exist on the remaining feedgrounds (Thorne et al. 1991). Only the NER winter feeds commingling populations of infected elk and bison.

Transmission of brucellosis between different species has been documented experimentally but only inferred under natural conditions. Under experimental conditions (i.e. confined animals) bison-to-cattle transmission is similar to cattle-to-cattle transmission (Davis et al. 1990). Transmission from ranched bison to cattle was inferred in 1983 in North Dakota (Flagg 1983) and suspected in South Dakota in 1987 (Davis 1991). Experimental transmission from infected elk to cattle has been shown by Thorne et al. (1979). Since achieving brucellosis-free status in 1985, Wyoming has had one outbreak of brucellosis in cattle, which was not attributable to cattle, in western Wyoming. This occurred in Fremont County, east of the Jackson bison and elk herds' distribution. Wildlife was implicated based on failure to find a cattle-related source (Bridgewater, USDA 1989, unpublished data). Prior to 1985, several outbreaks occurred in proximity to elk winter feedgrounds in the state, but no conclusive evidence implicating wildlife as the source of the disease was demonstrated. Because brucellosis is prevalent in elk fed on feedgrounds in Wyoming, however, and because these elk disperse after leaving the feedgrounds, elk as well as bison may be a potential source of brucellosis transmission to domestic cattle.

Although Brucella abortus has been isolated from several species of carnivores, it is not maintained in carnivore populations and their role in mechanically distributing brucellosis is unknown.

Generally speaking, three mechanisms exist for reducing the risk of transmission of brucellosis (and similar diseases). These include 1) decreasing the number of sources of infection, 2) decreasing the opportunity for transmission to occur, and 3) reducing the susceptibility of potential hosts.

In summary, the following management actions could be expected to reduce risk of brucellosis transmission from Jackson Hole bison to livestock:

1) Maintaining a relatively small bison herd size.
2) Separating and/or minimizing contact between bison and cattle.
3) Separating bison from other wildlife sources (e.g., elk).
4) Bison depopulation.
5) Testing and removal of brucellosis-infected bison.
6) Vaccinating adult bison may decrease transmission but the effect of strain 19 vaccination on infected pregnant bison is unknown.
7) Vaccination and surveillance of cattle that have potential for contact with JBH bison.
8) Increasing genetic resistance in cattle to brucellosis.

Framework for Alternative Development

Managing brucellosis in wildlife within the GYA is a complex issue and dilemma that wildlife and land managers must face. Brucellosis management is an issue because of the potential for transmission from wildlife to cattle. Management of brucellosis in the JBH, an integral part of the GYA, is complicated by several factors. The single most important factor is that the bison share winter and summer range with brucellosis-infected elk from the Jackson elk herd. While some elk were vaccinated on the NER between 1988 and 1991, a vaccination program alone will probably not remove elk as a source of reinfection for the JBH, or for domestic livestock. In the early 1970s (1971, 1973, 1974) brucellosis seroprevalence in elk averaged 46% among female elk at the Grey's River feedground (Smith et al. 1996). Ballistic vaccination with strain 19 commenced in 1985 and has continued for 12 years. Seroprevalence over the last 4 years (1993-1996) has averaged 22%, a statistically significant decline ($p=0.004$), and in 1996 dropped to 12% (Smith et al. 1996). On the NER, seroprevalence in elk was not statistically different from Grey's River feedground either in the 1970s or the 1990s (1993, 1995, 1996) (Smith et al. 1996) despite vaccination of only 40% of calf elk and 3% of adult female elk on the NER annually from 1989 to 1991. Seroprevalence on the NER following conversion from long hay to pelleted hay in 1975 declined ($p=0.01$) from 47% during 1971-75 to 28% during 1976-1985 (Smith and Roffe 1994). Elk vaccination may lower brucellosis seroprevalence, or natural cyclicity in brucellosis seroprevalence related to other factors may be occurring.

In light of the above, it is important to note that the viability of most disease management alternatives for the JBH is dependent upon removing the elk as a potential source of reinfection by 1) successfully separating the bison from wintering elk concentrations (i.e. on the NER), which is addressed under Management Issue IV: Winter Distribution, and 2) the eventual elimination of the disease in the Jackson Hole elk herd at some point in the future.

Alternatives Considered But Rejected:

1. Separating bison from domestic livestock. Permanently separating bison from domestic livestock would effectively eliminate the potential for disease transmission from bison to livestock. Even if bison were separated from domestic livestock, however, the potential for disease transmission from elk to livestock would remain. Separating bison from livestock would require 1) keeping the bison in a fenced enclosure year-round, which is contrary to the overall management goal of maintaining a free-ranging population, or 2) fencing cattle allotments on national forest, national park, and private lands, resulting in unacceptable impacts to other migratory wildlife, or 3) removing cattle from the lands in question, which would require an act of Congress and would result in economic impacts to the local ranching community. Consequently, separating bison from livestock is not considered feasible at this time, and it was rejected from further analysis.

Disease Management Alternative 1: No Action

Under this alternative, the status quo would be maintained, and efforts to manage disease would be limited to maintaining the herd at one of the population levels discussed under Management Issue I: Herd Size. No change in the prevalence of disease would be expected. The risk of disease transmission would be influenced only by the number of the animals in the herd.

Disease Management Alternative 2: Test and Removal

Under this alternative, attempts would be made to round up and test all the female bison in the JBH for brucellosis. Females that tested positive would be removed from the population. This alternative assumes that infected males are epidemiologically unimportant (i.e. they do not transmit the disease) and they would be left in the herd. To hold and test the bison, a large trap and handling facility would have to be constructed, as discussed under Management Issue II: Herd Reduction Methods, Alternatives 4 and 6. Under this alternative the JBH could, over a relatively short period of time, be made brucellosis-free. This would require labor intensive capture, testing and retesting (to confirm screening tests), and slaughter of seropositive animals.

Assuming approximately 77% seroprevalence in the herd (males 84%, females 69%) and a 1:1 cow:bull distribution of positive animals, such a process would remove an estimated 38 females from a herd of 110 head, 69 females from a herd of 200 head, 86 females from a herd of 250 head, or 138 females from a herd of 400 head. The herd would have to be retested at predetermined intervals because the incubation period for brucellosis can cause false negative test results. As seronegative females convert to seropositive, retesting would identify additional animals for removal. Females could either be culled or sterilized, effectively removing them from the reproductive herd. Whether the brucellosis-free status of the herd would persist is questionable, since reinfection from Jackson elk would likely occur in time.

Disease Management Alternative 3: Vaccinate with Strain 19

Strain 19 is the vaccine that has been used since the 1940s to protect cattle against brucellosis. It is also used in domestic and some wild bison herds under the assumption that efficacy in bison is the same as in cattle. Recent research on strain 19 in bison, however, has found no efficacious dose of strain 19 that adequately protects bison calves or adults against abortions or infections (Davis et al. 1991, Davis 1993).

Strain 19 appears to offer no protection when administered to bison calves (Davis 1990b). Some protection is afforded when used on adults. Vaccination of adult female bison effectively reduces abortion by 67-79%, thereby decreasing the potential for disease transmission. Protection is incomplete, however, and protection against subsequent infection is poor (38-50%). In recent tests, vaccination also induced a high rate of abortion (50-66%), one repeat abortion, and possible persistent infections (Davis et al. 1991). Consequently, adult vaccination could be expected to: 1) provide some decrease in disease prevalence, 2) cause abortion in most previously uninfected pregnant females, 3) decrease the ability to measure true disease prevalence because the vaccine confuses serologic testing for the disease, 4) decrease the ability to measure risk to livestock because of unclear serologic test results (see Appendix VII), 5) result in strain 19 shedding into the environment, and 6) result in some chronic strain 19 infections in vaccinated animals. The effect of vaccination on previously infected pregnant bison is unknown.

Development of 1) a safe and effective dose of strain 19 vaccine, and 2) tests that differentiate seropositive results of vaccinated versus field strain-infected animals are needed before strain 19 vaccination can be considered a viable alternative for disease control. The development of an efficacious dose and new diagnostic technology could be expected only to lower prevalence of brucellosis and not to eliminate the disease (Peterson 1991).

Vaccine could be remotely administered when the bison are on wintering grounds via a biobullet, a lightweight pellet containing vaccine propelled by a compressed air gun, or hand-injected during trapping and handling procedures. Research is currently being conducted on an orally administered vaccine that may be available for treating bison in the future (see Davis 1996).

Several alternative vaccines to strain 19 are currently being researched. These include RB51, a mutant strain of Brucella abortus, and Brucella neotomae. Preliminary results of RB51 research indicate some efficacy in cattle, but abortions and infections have been reported in pregnant adult-vaccinated bison (Philo 1996). Ongoing research on calfhood vaccination with RB51 is incomplete, but preliminary results suggest the vaccine may be safe (S. Olsen, Agricultural Research Service, USDA, pers. comm. 1996). B. neotomae, a naturally occurring Brucella species found in desert wood rats (Neotoma lepida), has not been shown to be pathogenic to other host species. This organism has caused immunological response in mice, swine and bison (Davis in prep.) and has shown some promise as an oral vaccine.

Another potential brucellosis vaccine is Brucella suis, biovar 2, which has been used extensively in China for years (Xin 1986). The organism, however, is not native to North America and would face resistance and extensive testing before being used in this country.

Disease Management Alternative 4: Depopulate and Re-establish the Herd from Brucellosis-Free Stock

Under this alternative the entire JBH would be destroyed through one or more of the reduction methods discussed under Management Issue II: Herd Reduction Methods. Certified brucellosis-free bison would then be introduced into the valley to re-establish the population. The number of bison introduced would depend on the desired herd size, but may be significantly less than the population objective due to availability of bison or logistical constraints. If fewer animals were introduced, some time would elapse before the desired level was reached. This alternative would represent the most rapid method of establishing a brucellosis-free herd. In time, reinfection of the bison from Jackson elk would be likely.

Disease Management Alternative 5: Minimize the potential for brucellosis transmission between bison, domestic livestock, and other wildlife while working toward elimination of the disease (PREFERRED ALTERNATIVE)

Under this alternative, a variety of management actions would be taken to minimize the potential for brucellosis transmission among bison, elk, and domestic livestock, with the eventual goal of eliminating the disease. Management actions that would take place immediately include 1) actions to separate bison from brucellosis-infected elk on wintering grounds (Alternatives 2-5 under Management Issue III: Winter Distribution), and 2) attempts to separate bison from domestic livestock both geographically and temporally. Other actions that would be taken include recommending vaccination of all cattle grazed on federal lands within Jackson Hole and vaccinating bison against brucellosis when an effective vaccine becomes available. The Technical Subcommittee of the Greater Yellowstone Interagency Brucellosis Committee would provide guidance to the management agencies on alternatives, including vaccination, for brucellosis management.

The likely source of the JBH's current brucellosis infection was infected elk on the NER. The most likely period for intra- and interspecific brucellosis transmission is during late pregnancy, when abortions are likely, and during parturition. Therefore, efforts to reduce brucellosis infection rates in bison necessitate the separation of bison from elk during winter and spring and/or concurrent efforts to decrease brucellosis in elk wintering on the same range as the JBH. Under this alternative, efforts to separate bison from elk would be made by implementing one of Alternatives 2-5 under Management Issue III: Winter Distribution.

The potential for brucellosis transmission is greatest February through June, during the latter two trimesters of pregnancy. A variety of measures would be recommended to minimize the potential for contact between bison and domestic livestock during this period through both geographical and temporal separation, thereby minimizing the potential for brucellosis transmission. Areas where cattle allotments or driveways currently overlap with potential bison calving areas during May and June include the Kelly Hayfields and adjacent areas south of Blacktail Butte and northeast of Kelly, Ditch Creek, Antelope Flats, the Cunningham pasture, and the Elk Ranch pasture west of Highway 89 (Smith and Robbins 1994, GTNP unpublished data). Spring turn-on dates for these areas range from May 15 in the south to June 15 in the north. The majority of land in these areas is under federal ownership, but some private lands also exist. The agencies responsible for issuing grazing and trailing permits in these areas would work with permittees to revise turn-on dates in the spring and/or encourage trucking of livestock between pastures.

Commercial grazing of livestock in GTNP was authorized to continue generally as conditions existed when the Park's enabling legislation was passed in 1950. Section 1 of Public Law 81-787 (64 Stat. 849) guarantees livestock grazing permittees all valid rights that existed when the Park was established. Legislation establishing the Park clearly expressed the intent to eventually eliminate grazing in the Park and provided a structure for terminating permits based on valid (1950) permit holders' lifetimes, or their children's lifetimes. As a result, permits for grazing in the Park have declined from 29 in 1950 to 6 (3 for cattle, 3 for horses) in 1996. Livestock driveways through the Park, connecting private ranch base lands to allotments on other federal lands, however, were to be permitted for as long as they are needed. Consequently, GTNP cannot require that current permittees substantially modify grazing practices. Park officials would recommend to permittees modifications of grazing practices that would reduce disease risk and work with them to implement operational procedures wherever possible.

Forest Service policy is to notify livestock permittees that some of the Jackson Hole bison have brucellosis and to inform permittees of actions they could take to minimize the transmission of brucellosis from bison to livestock. If a permittee requests a change in his/her Operating Plan or Allotment Management Plan to reduce the risk of brucellosis transmission to livestock, the Forest Service will accommodate the request, within cost constraints.

At present there is no known effective vaccine for brucellosis in bison (see Appendix VII and discussions for Management Issue IV: Disease Management Alternatives under

MANAGEMENT ISSUES AND ALTERNATIVES and ENVIRONMENTAL CONSEQUENCES). Promising research is underway, however, on 2 separate vaccines: Brucella neotomae and RB51 (D. Davis, Texas A&M University, pers. comm.). B. neotomae has shown favorable results when administered orally to bison (Davis et al. in prep.), which has important implications for vaccination of free-roaming wildlife. This vaccine is not yet available. RB51, a man-made mutant of field strain Brucella abortus Biovar 1, is currently being tested on elk and bison. Preliminary results indicate some problems with pregnant adult bison vaccination and safety concerns in calves (Philo 1996, Olsen 1996). Neither vaccine has had extensive testing for pathogenicity in non-target species. B. neotomae, however, is a naturally occurring Brucella that, in preliminary tests, has not demonstrated pathogenicity in other species.

Under this alternative, the JBH could be vaccinated against brucellosis when a safe and effective vaccine becomes available, including new vaccines or modifications of strain 19 dosage. The GYIBC technical subcommittee would be used to provide guidance on the use of brucellosis vaccines. The opportunity for success of any long-term reduction in the prevalence of brucellosis in the JBH would be enhanced by maintaining spatial separation of bison and brucellosis-infected elk during winter and spring and/or ultimately eliminating brucellosis from elk.

Risk assessments for the probability of disease transmission between wildlife and domestic livestock are an important management tool. Peterson et al. (1991) modelled brucellosis prevalence in the JBH under a variety of disease management scenarios, but did not assess the relative risks of transmission to livestock. Under this alternative, the agencies would pursue development of an assessment of transmission risk based on temporal and spatial distribution of bison and livestock and the epidemiology of brucellosis. GTNP is preparing to contract the development of a brucellosis risk assessment for bison, elk, and domestic livestock, beginning in 1997, that will be funded with NPS brucellosis research grants.

SUMMARY OF ENVIRONMENTAL CONSEQUENCES (preferred alternatives shaded)

Table 4. Summary of Environmental Consequences: Herd Size

Impacts On:	Alternative 1: No Action	Alternative 2: 90 - 110	**Alternative 3: 200-250**	Alternative 4: 350-400
Wildlife and Vegetation	- elk would be displaced in some areas. Fewer elk would exist in the Jackson herd due to competition - increased carrion would benefit scavengers - local plant communities would be changed over time, and exotics could increase - plant and animal species diversity could increase in some areas	- all impacts would be minor and would be the least of any of the alternatives considered - some elk would continue to be displaced on summering and wintering grounds - less carrion would be available to scavengers	**- all impacts would be minor and would be similar to Alternative 2**	- all impacts would be minor and would be the same as under Alternatives 2 and 3 except that they would occur at a slightly greater magnitude - bison could compete with elk if herd continued wintering on NER
Endangered Species	- grizzly bears, gray wolves, and bald eagles could benefit from increased prey and/or carrion	- due to reduced prey and/or carrion, the least potential for positive impacts on T&E species would occur	**- for eagles, bears, and wolves: slightly higher potential for prey and/or carrion availability than Alternative 2, lower than Alternatives 1 and 4**	- for eagles, bears, and wolves: slightly higher potential for prey and/or carrion availability than Alternatives 2 or 3, but lower than Alternative 1
Visual Resources and Recreation	- bison visibility and associated recreation would increase - potential for bison-human conflicts would increase - erosion due to overgrazing and wallowing could have negative impacts - spread of exotic plants could increase	- bison visibility and potential for associated recreation would be the lowest among the alternatives - potential for bison-human conflicts would be low	**- bison visibility and potential for associated recreation not significantly different than Alternative 2 - potential for bison-human conflicts would remain low**	- bison visibility and potential for associated recreation would increase slightly over Alternatives 2 or 3 - potential for bison-human conflicts would remain low

Table 4 (continued). Summary of Environmental Consequences: Herd Size

Disease Management	- the potential for disease transmission to domestic livestock would be the highest among alternatives - disease management options that involve handling animals (trap and slaughter or vaccination) would be extremely difficult	- the potential for disease transmission to domestic livestock would be the lowest among alternatives - disease management options that involve handling animals would have the greatest chance of success	**- the potential for disease transmission to domestic livestock would be greater than Alternative 2, but less than Alternatives 1 or 4** **- disease management options that involve handling animals would be more difficult than under Alternative 2**	- the potential for disease transmission to domestic livestock would be greater than Alternatives 2 or 3, but less than Alternative 1 - disease management options that involve handling animals would be more difficult than under Alternatives 2 or 3
Herd Integrity	- herd integrity would benefit more than under any other alternative - periodic bison introductions would not be necessary once population grew larger than 400	- Alternative presents greatest potential for loss of heterozygosity and herd integrity - an introduction of more than 7 successfully reproducing female bison per generation would be necessary to maintain heterozygosity	**- herd integrity would be protected** **- 3-5 reproductively active female bison would be introduced every generation (7 years) to ensure heterozygosity is maintained**	- herd integrity would be protected to a greater extent than under Alternatives 2 or 3 - introductions of bison (genetic material) from other populations may not be necessary
Socio-Economic Factors	- highest agency administrative costs - greatest potential for property damage - increased recreation opportunities and administrative expenditures could incur positive benefits to local economy	- lowest agency cost - least potential for property damage - little effect on local economy	**- similar to Alternative 2**	- similar to Alternatives 2 and 3 - slightly higher potential for property damage

PREFERRED ALTERNATIVE

Table 5. Summary of Environmental Consequences: Herd Reduction Methods

Impacts On:	Alternative 1: Sterilization or Contraception	Alternative 2: Agency Reductions	Alternative 3: Public Hunt Reduction	Alternative 4: Trap and Transport to Quarantine	Alternative 5: Native American Hunt Reduction	Alternative 6: Trap, Test, and Slaughter	**Alternative 7: Public Hunt / Reduction for Native American Use**
Wildlife and Vegetation	- no direct impacts anticipated - possible decrease in availability of prey or carrion - construction of holding facilities could displace other wildlife	- no direct impacts anticipated - may be temporary displacement of elk during reduction activities (late winter)	- no direct impacts anticipated - may cause temporary displacement of elk and reduced elk use of northern portion of NER	- reduced forage for elk on NER due to construction of facilities - potential for disruption of migration corridors - some injuries to bison likely	- no direct impacts anticipated - may cause temporary displacement of elk and reduced elk use of northern portion of NER	- impacts similar to Alternative 4, except that injuries to bison associated with transport would not occur	**- no direct impacts anticipated** **- may be temporary displacement of elk during reduction activities (late winter)**
Endangered Species	- no impacts anticipated	- no impacts anticipated	- no impacts anticipated	- no impacts anticipated	- no impacts anticipated	- no impacts anticipated	**- no impacts anticipated**
Visual Resources and Recreation	- lowered aesthetic value due to fewer or no calves in herd - trapping and handling facilities would have visual impact if located in public use areas - opportunity for hunting would be decreased or eliminated	- no impacts anticipated. Culling would occur when bison are concentrated in areas closed to the public	- no impacts to visual resources - hunting would increase recreation opportunities	- facilities could have visual impact on NER - NER elk hunt could be disrupted - no public hunting opportunities	- no impacts to visual resources - no public hunting opportunities	- facilities could have visual impact on NER - NER elk hunt could be disrupted - no public hunting opportunities	**- no impacts to visual resources** **- limited "fair-chase" hunt would provide recreation opportunities** **- agency costs would be somewhat higher than Alternative 2**

PREFERRED ALTERNATIVE

Table 5 (continued). Summary of Environmental Consequences: Herd Reduction Methods

Disease Management	- reduction in potential for transmission of brucellosis - holding pens and other facilities could be used for disease management activities	- no impacts anticipated - risk of brucellosis transmission greater than Alternative 1	- no impacts anticipated - risk of brucellosis transmission similar to Alternative 2	- handling facilities would aid some disease mgmt. alternatives - brucellosis seroprevalence in the herd would probably increase because only disease-free bison would be transported to quarantine	- no impacts anticipated - risk of brucellosis transmission similar to Alternative 2	- handling facilities would aid some disease mgmt. alternatives - brucellosis seroprevalence in the herd would probably decrease because test-positive bison would be destroyed	**- no impacts anticipated** **- risk of brucellosis transmission similar to Alternative 2**
Herd Integrity	- with sterilization, potential for stagnation of gene pool, high inbreeding, loss of heterozygosity over time - with reversible contraception, genetic potential of each animal would be retained	- population structure would be regulated by selecting bison to be culled, thereby maintaining genetic integrity	- population structure would be regulated by selecting bison to be culled, thereby maintaining genetic integrity	- population structure would be regulated by retaining disease-free bison in the herd if necessary to achieve desired sex and age ratios	- population structure would be regulated by selecting bison to be culled, thereby maintaining genetic integrity	- population structure would be regulated by selecting bison to be culled, thereby maintaining genetic integrity	**- population structure would be regulated by selecting bison to be culled (other than small number taken in "fair chase" hunt), thereby maintaining genetic integrity**
Socio-Economic Factors	- labor intensive with high associated costs for implementation - potential benefits to local economy through labor required	- would require some agency time, but costs less than Alternative 1	- high administrative costs - state revenues generated through licenses - greatest positive impact on local economy	- highest direct agency cost of any of the alternatives except possibly Alt. 1 - no hunting revenues - potential benefits to local economy through materials and labor required	- costs similar to Alternative 3, depending on fees charged, if any - would provide cultural and economic benefits to Native Americans	- impacts would be similar to Alternative 4, but facilities would be smaller and cost less	**-agency costs would be somewhat higher than Alternative 2** **- Additional recreational benefits from "fair chase" hunt** **- would provide economic benefits to Native Americans**

PREFERRED ALTERNATIVE

Table 6. Summary of Environmental Consequences: Winter Distribution

Impacts On:	Alternative 1: No Action	Alternative 2: Fence Bison At Hunter-Talbot	Alternative 3: Feed Bison At Hunter-Talbot	**Alternative 4: Modify Bison Winter Distribution**	Alternative 5: Fence Bison At National Elk Refuge
Wildlife and Vegetation	- bison would continue to displace elk from feedlines - competition for standing forage between elk and bison would continue, requiring longer supplemental feeding - bison rubbing would continue to damage trees (a limited resource on the NER) used as perch sites for many birds - wallowing and grazing may increase local habitat and species diversity	- impacts on wintering elk would be avoided - resuming irrigation of Hunter-Talbot would affect Ditch Creek riparian corridor - vegetation damage would occur in the fenced area within GTNP - some local interference with elk, deer, and moose movements might occur - possible adverse response of bison to confinement	- impacts on wintering elk would be avoided - vegetation damage would occur at feeding area - resuming irrigation of Hunter-Talbot would affect Ditch Creek riparian corridor - very limited competition with elk could occur - feeding could attract and habituate free ranging elk and moose	**- impacts on wintering elk would be avoided** **- some vegetation damage would occur at feeding area** **- resuming irrigation of Hunter-Talbot would affect Ditch Creek riparian corridor** **- native forage utilization would be increased** **- potential for competition with elk would be greater than Alternative 3, less than Alternative 1** **- natural herd regulation factors would help limit need for reductions**	- some vegetation damage within the enclosure would occur - less natural forage would be available to wintering elk - possible adverse response of bison to confinement - some local interference with elk, deer, and moose movements might occur
Endangered Species	- generally little impact expected - potential to damage perch trees used by bald eagles	- none anticipated	- none anticipated	**-if winter mortality increases, more carrion would be available to grizzly bears, bald eagles, and perhaps gray wolves**	- none anticipated
Visual Resources and Recreation	- viewing opportunities would continue to be limited in winter	- viewing opportunities would be limited in winter - enclosure and vegetation damage within it would detract from Park's natural setting	- opportunities for winter viewing of bison would be enhanced - visual impacts from vegetation damage would be minimal	**- opportunities for winter bison viewing would be greater than under any of the other Alternatives**	- no opportunities for observing wintering bison would exist

Table 6 (continued). Summary of Environmental Consequences: Winter Distribution

Disease Management	- the potential for inter- and intraspecific transmission of disease would remain high - Brucella seroprevalence would probably remain high in bison and elk - Supplementally feeding brucellosis-infected elk and bison together would complicate disease management efforts	- less chance than Alternatives 1, 3, & 4 for interspecific transmission of disease - bison likely to maintain a high Brucella seroprevalence - ability to handle bison for disease treatment would be enhanced in enclosure	- bison likely to maintain a high Brucella seroprevalence - potential for disease transmission between bison and elk would be lower than Alternative 1 but higher than Alternatives 2 or 5	**- potential for exposure to Brucella-contaminated tissues from elk would be reduced** **- potential for disease transmission between bison and elk would be lower than Alternative 1 but higher than Alternatives 2 or 5**	- less chance than Alternatives 1, 3, & 4 for interspecific transmission of disease - bison likely to maintain a high Brucella seroprevalence - ability to handle bison for disease treatment would be enhanced in enclosure
Herd Integrity	- no effect	- no effect	- no effect	**- no effect**	- no effect
Socio-Economic Factors	- little winter recreational opportunity and no benefit to local economy from winter bison viewing	- high administrative cost associated with materials, feed, and labor - some benefit to local economy through expenditures for materials and labor	- high administrative costs associated with feeding, need for patrols and increased signing	**- similar to Alternative 3 with reduced costs for feed and labor**	- similar to Alternative 2, but more costly if double fence is built

PREFERRED ALTERNATIVE

Table 7. Summary of Environmental Consequences: Disease Management

Impacts On:	Alternative 1: No Action	Alternative 2: Test and Removal	Alternative 3: Vaccinate With Strain 19	Alternative 4: Depopulate and Reestablish	**Alternative 5: Minimize Disease Transmission**
Wildlife and Vegetation	- high Brucella seroprevalence would be maintained in bison, resulting in some bison calves lost to abortion. The abortion rate in the JBH is unknown.	- wildlife would be excluded from handling facility areas - some vegetation would be damaged at handling facility site - less carrion would be available to scavengers due to the removal of large numbers of infected bison	- no impacts anticipated if remote delivery was used - capture and hand injection would result in excluding wildlife from handling facility areas and some localized vegetation damage	- the entire bison herd would be destroyed - knowledge of seasonal ranges, calving areas, etc. would be lost - new and unforeseeable impacts could occur depending on the behavior and established distributions of introduced bison	**- similar to Alternative 3**
Endangered Species	- none anticipated	- less carrion would be available to grizzly bears, bald eagles, and gray wolves	- none anticipated	- less carrion would be available between depopulation of the herd and restocking	**- none anticipated**
Visual Resources and Recreation	- none anticipated	- opportunities for viewing bison would be reduced initially, and may or may not rebound depending on disease prevalence	- none anticipated	- viewing opportunities would be completely lost between depopulation of the herd and restocking - new and unforeseeable impacts may occur depending on the behavior and established distribution of introduced animals	**- none anticipated**

Table 7 (continued). Summary of Environmental Consequences: Disease Management

Disease Management	- no change in disease prevalence among bison - no change in potential for disease transmission to livestock	- herd could be brucellosis-free in short period of time - current disease conditions would probably return unless bison were separated from elk	- brucellosis prevalence may be lowered if adults were vaccinated. The minimum age for effective vaccination is unknown. - would cause abortion in most vaccinated, pregnant females, confuse serologic picture, shed S-19 into environment, cause some persistent infections	- herd could be brucellosis free in short period of time - new herd could be reinfected by elk - changes in herd's behavior and distribution may have implications as of yet unknown	**- would depend on cooperation with ranchers and success of bison-livestock separation efforts, development of effective vaccine, and success of bison-elk separation efforts**
Herd Integrity	- no effect	- decreasing herd size and loss of genetic material would compromise herd integrity initially - genetic introductions may be necessary	- no effect	- the current herd integrity and genetic identity would be destroyed - the future herd's integrity would depend on the genotype of donor populations and the agreed upon size of the new herd	**- none anticipated**
Socio-Economic Factors	- no changes expected	- highest administrative cost - reduced herd size would have negative effect on local economy through lost recreation opportunities	- administrative costs variable depending on how vaccine is administered - no effect on local economy expected	- agency costs variable depending on bison source for repopulation - few long term impacts on local economy - some short term impacts associated with reduced recreation opportunities	**- possible increased operating costs to livestock industry** **- costs of delivering new vaccine unknown**

PREFERRED ALTERNATIVE

ENVIRONMENTAL CONSEQUENCES

MANAGEMENT ISSUE I: HERD SIZE

Herd Size Alternative 1: No Action

Under this alternative the JBH would be allowed to self-regulate. The Ricker approximation of a logistic growth model (M. Boyce, Univ. Wisconsin, pers comm. 1996), based on 15 years of empirical growth data from the JBH, predicts that the herd would start to level off at around 1100 bison within about 35 years (Fig. 5). Assuming that this model approximates actual growth of the herd, the herd could number approximately 400 animals in 5 years, 600 animals in 10 years, and over 900 animals in 20 years (Fig. 5). Even though the effects of biases are small for this particular model (M. Boyce, Univ. Wisconsin, pers. comm. 1996), actual herd growth patterns may diverge from these estimates due to biases inherent in growth models and other ecological factors that the model may not account for.

Impacts On Wildlife and Vegetation. As the herd grows larger under this alternative, impacts on wildlife and vegetation would be expected. Since bison and elk use many of the same forage species (Telfer and Cairns 1979) and occupy many of the same areas, the impacts of bison on elk would increase as numbers of bison increase. Because of their relative size and disposition, bison readily displace elk where limited common resources occur (Helprin 1992). Consequently, elk would be displaced in some areas as the bison herd expands its range to accommodate growing numbers. Bison impacts on elk would be greatest during periods when high quality forage is in critical demand, such as during drought years and during especially cold or snowy winters. These impacts would become significant at some unknown bison population level. If bison continued to frequent the NER, less natural forage would be available for elk on their wintering grounds, which would necessitate extended periods of supplemental feeding or a reduction in elk numbers. Some negative impacts on mule deer may also occur, but since bison and deer diets are largely different, these impacts would probably be negligible. No impacts on moose are anticipated.

Large numbers of bison could have beneficial effects on other species. Through the effects of grazing and creation of wallows, bison can increase habitat diversity, which in turn increases species diversity. Collins and Barber (1985) found that in grassland ecosystems, community diversity is maximized under a natural disturbance regime, including bison grazing and wallowing. Heavy grazing by bison favors browse and forb species, which compose the primary diet of pronghorn antelope. Thus grazing by bison may create favorable conditions for pronghorn in grassland ecosystems (England and DeVos 1969). In GTNP, bison and pronghorn use many of the same areas during spring, summer, and fall. Scavengers such as eagles, coyotes, ravens, and magpies would also benefit from an increase in available carrion that would result from large numbers of bison.

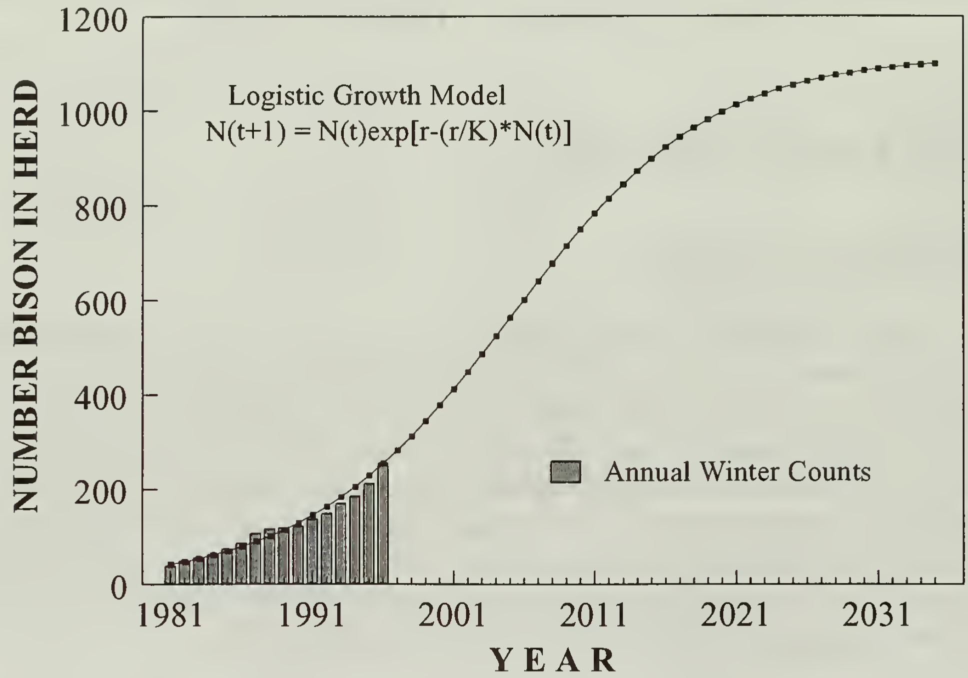

Figure 5. Projected growth of the Jackson bison herd based on the Ricker model approximation of logistic growth using 15 years of JBH growth data as measured from annual winter counts.

Bison would affect vegetation by grazing, wallowing and rubbing. At high bison numbers, severe overgrazing in high use areas could cause changes in local plant communities, benefit pioneer species, and possibly result in increased establishment of exotic and/or non-palatable species over time. Wallowing by large numbers of bison would completely remove vegetation from selected areas. Erosion from both overgrazing and wallowing could affect other vegetation. Erosion and associated effects on vegetation near favored watering areas would also occur. The various effects of bison on vegetation would probably be localized, and may be particularly focused on the Snake River riparian areas between Deadman's Bar and Moran, where the bison spend much of the summer.

In summary, under this alternative bison would have the potential to alter the plant and animal communities in some areas of Jackson Hole over time. Elk from the Jackson elk herd would be the most affected of all wildlife. As bison numbers grow, Jackson Hole could be expected to support fewer numbers of elk. In addition, elk mortality during drought years and cold, snowy years would increase. Overgrazing and wallowing would alter plant communities in some areas over time. Depending on the level of disturbance created by bison, plant and animal species diversity could be increased in some areas.

Impacts On Endangered Species. This alternative could benefit both the grizzly bear and gray wolf by providing an increased source of prey and carrion. This would be especially true for grizzly bears if some bison wintered in the northern end of the valley. As bison numbers increased, distributions would be expected to increase, and larger numbers of bison might frequent areas where grizzly bears are now well established. In Wood Buffalo National Park in Canada, bison are a primary prey of wolves (Carbyn et al. 1993). Therefore larger numbers of bison in Jackson Hole would be expected to benefit wolves dispersing from Yellowstone and establishing territories within the JBH's range. Bald eagles would also benefit under this alternative through the greater abundance of available carrion. No effect of this alternative is anticipated on either the peregrine falcon or whooping crane.

Impacts On Visual Resources And Recreation. Under this alternative, visual resources and recreation would incur both positive and negative impacts. As the herd increased in size, bison would be visible more often and in more areas, positively affecting the natural scene. Non-consumptive recreation opportunities associated with bison such as viewing and photographing would increase. Small, localized areas denuded of vegetation by bison wallowing or overgrazing could exist, which, from some perspectives, might detract from the aesthetics of the valley.

An expanded distribution of bison would also create a greater potential for recreationist-bison conflicts, especially during the summer. Bison could be expected to move into areas around Jenny Lake, the Oxbow, Colter Bay, and the Triangle X dude ranch, which are all popular visitor areas. Temporary closures of high bison use areas to the public would probably be necessary, resulting in restricted recreational use. "Bison jams," where large numbers of visitors stop to view bison and disrupt traffic flow along park roads, would also increase. Situations similar to those along roads in Yellowstone National Park could become common in Jackson Hole. On the NER, greater numbers of bison would increase the potential for conflicts between bison and visitors along the Refuge road. Bison could present a threat to human safety in these and other areas, and the potential for human conflicts would increase. Each winter and spring, before supplemental feeding begins and after it ends, bison travel widely on the NER, including southward along the Refuge road toward the town of Jackson. Since 1985, when the number of bison on the NER surpassed 75, the level of hazing required to avert bison-pedestrian conflicts on the Refuge road and to prevent bison from entering town has increased. For example, during winter 1985-86 bison were hazed on 17 days. During spring 1996, bison were hazed on 30 days to discourage as many as 175 from trailing south on the Refuge road.

Impacts On Disease Management. Although there is some evidence in cattle that larger herd sizes have higher disease prevalence (Crawford et al. 1990), for purposes of this analysis it is assumed that disease prevalence will not change significantly as the bison population increases in size. By allowing herd growth to continue unrestrained, this alternative would increase the potential of disease transmission from bison to livestock over time. Mechanisms responsible for the increased risk include greater numbers of potential transmitters within current ranges as well as greater numbers in new, expanded ranges. The latter would increase the direct probability of interaction with livestock as the growing population expanded into new habitat and established larger distributions. The most likely areas for calving season range expansion (when brucellosis transmission is most likely) are in the Gros Ventre pasture, Wyoming State school section 36 in GTNP, the Gros Ventre River drainage, and the Uhl Hill-Spread Creek area. All of these areas contain cattle during part of the bison calving season. During winter bison may also expand their distribution to areas of private land where cattle are wintered, which may also increase the risk of disease transmission. Since transmission of brucellosis from free-ranging bison to domestic livestock has never been documented, probable transmission rates associated with different herd levels are unknown and cannot be estimated. Nevertheless, since it is reasonable to expect the probability of disease transmission to increase with increasing numbers of bison, this alternative may represent a greater threat to domestic livestock than do the other herd level alternatives.

Under this alternative, disease management alternatives that involve accessing or handling all the bison in the herd (i.e. trap and slaughter/transport; vaccinate) would become extremely difficult and probably impossible to implement over time. As the herd level increased, numbers of animals that stray from or consistently use areas outside of those used by the majority of the herd would increase. More bison would winter and summer away from traditional use areas. Consequently, containing the entire herd at one time for handling and/or vaccinating would be extremely difficult, which would severely limit the effectiveness of these disease management alternatives.

Impacts On Herd Integrity (genetics). Of all the herd level alternatives considered, this alternative would have the most beneficial effect on herd integrity. As the number of animals in the herd increased, the effective population would also increase. As the effective population increased, inbreeding coefficients (a measure of the degree of inbreeding within a population) would decline. Lower inbreeding coefficients result in greater genetic variability over time, which in turn results in greater overall fitness of the population and the ability to adapt to changes in the environment. Under this alternative, once the bison herd reached and exceeded 400 animals, N_e would be greater than or equal to 100 (see Table 2) and introductions of bison from other populations would not be necessary.

Impacts On Socio-economic Factors. Few socio-economic impacts would be expected under this alternative. The larger herd size would increase recreation opportunities associated with bison in the area. Depending on the ultimate size the bison herd attained, some localized erosion could reduce the quality of the overall recreation experience in the area, but these effects would probably be insignificant. Since bison are native to the area, most visitors would probably accept their wallows and other impacts as part of the natural scene. The potential for property damage under this alternative would be the highest of all the alternatives because of the larger herd size. The larger herd size also may increase the potential for disease transmission to domestic livestock. The administrative costs to the management agencies would also be the highest under this alternative due to increased monitoring costs and the potential for increased conflicts among bison, livestock, and humans.

The impact on the local economy is unlikely to be large under this alternative. Because there are abundant opportunities to view bison in Yellowstone National Park, the number of recreation visitors and average length of stay in the area are not likely to change significantly with an increase in the local herd size. Increased property damage, if such occurs, could have a negative effect on the local economy. The Wyoming Game and Fish Department does not compensate landowners for damage caused by bison to fences, livestock, or other real property. Compensation is limited to damages to stored or field crops or other agricultural production. The local economy would gain from increases in administrative costs to the extent that these expenditures involve purchases of local goods, services, and labor.

Herd Size Alternative 2: Herd Size of 90-110

Under this alternative the herd would be maintained at 90-110 animals, the same level called for under the 1988 interim plan. The herd would be periodically culled to maintain these numbers through one or more of the herd reduction alternatives discussed under Management Issue II: Herd Reduction Methods.

Impacts On Wildlife and Vegetation. The number of bison in the Jackson herd has exceeded 100 since 1987 (Fig. 3). Numbers of other ungulates (deer, moose, elk, pronghorn) in the valley either increased or remained stable during at least the 6 subsequent years (WGFD Annual Completion Reports 1987-1992), indicating that a bison herd of this size would have negligible impacts on these species. Declines in deer and pronghorn populations beginning in 1992 were due to severe winter weather and harvest strategies and were unrelated to bison numbers. Locally, the bison would displace elk on parts of their summer ranges (particularly in the Snake River bottoms). At current herd levels, however, summer range is not limiting for moose, deer, pronghorn or elk. Consequently, local displacements would have little or no impact. The potential for bison to create favorable conditions for pronghorn and other species (discussed under Alternative 1) would also apply here, but would occur at a lower level than under any of the other alternatives.

If bison continued to frequent the NER during winter, less natural forage would be available for elk than there would be in the absence of bison. In addition, supplemental feeding of bison would be required to keep them from disrupting elk feeding operations. Neither of these conditions, however, has the potential for significant impacts on the Jackson elk herd.

Compared to Alternative 1, a smaller bison herd would have negative impacts on some carnivores and carrion-eating animals. A smaller herd size would result in less carrion available for scavengers such as eagles, coyotes, ravens, and magpies.

Impacts of bison on vegetation would include grazing, wallowing, and rubbing. During the last 9 years, however, when the bison herd has exceeded 100 animals, no significant impacts have been observed. Bison wallows are now evident in most of their summering areas and have altered some local plant communities. But since bison are native to Jackson Hole, this alteration is not considered a negative impact, except to the extent that it may increase the potential for exotic plant establishment. As mentioned above, wallowing can increase plant and animal species diversity.

In summary, no significant impacts on wildlife or vegetation are anticipated under this alternative.

<u>Impacts on Endangered Species</u>. Compared to the other herd size alternatives, this alternative would have the least potential for positive impacts on endangered species. By providing an additional source of prey and/or carrion, a herd of this size would provide a small and probably insignificant benefit to bald eagles and grizzly bears, and possibly to gray wolves in the future. No effect of this alternative is anticipated on either the peregrine falcon or whooping crane.

<u>Impacts On Visual Resources and Recreation</u>. Because this alternative allows the smallest herd size of the alternatives considered, it would provide the lowest level of non-consumptive recreation opportunities, such as viewing and photographing bison. Hunting opportunities would also be less with a smaller herd size, if hunting is selected as a herd reduction alternative. Bison distribution and movement patterns would be expected to remain the same as they were when the population was approximately this size between 1987 and 1990. The probability for bison-recreationist conflicts would be the lowest of all the alternatives and the bison population would not cause significant management or recreation impacts. Temporary closures would probably not be necessary, and "bison jams" would occur relatively infrequently. The impacts of bison on vegetation would not detract from the natural scene.

<u>Impacts On Disease Management.</u> Because fewer bison would exist in Jackson Hole under this alternative, the possibility of disease transmission from bison to domestic livestock or other wildlife would probably be less than it would be under the other alternatives, even though the disease prevalence in the herd would not be expected to change. In addition, bison would be less likely to wander outside of habitually used areas, which are largely free of domestic livestock use. Since transmission of brucellosis from free-roaming bison to domestic livestock has never been documented, probable transmission rates associated with this herd size are unknown and cannot be estimated. Disease management alternatives that require accessing or handling bison would have a better chance of success under this alternative compared to all the other alternatives.

<u>Impacts On Herd Integrity</u>. Although most knowledge of population genetics in wild populations of large mammals is theoretically based, current understanding indicates that a herd size of 90-110, even under ideal conditions, would result in loss of genetic variability over time. A herd of 100 bison would have an estimated N_e of 25 without induced

immigration, which is substantially below recommended minimums (Shelley and Anderson 1989, Berger 1996). Long-term maintenance of genetic variability, without induced immigration, would require a herd size of about 400 bison (Table 2, Berger 1996). Because of the small herd size, this alternative presents the greatest potential for loss of heterozygosity and thus herd integrity.

To compensate for the potential loss of alleles (i.e. heterozygosity) at a herd level of 90-110, periodic introductions of bison from other herds would be necessary (Shelley and Anderson 1989, Berger 1996). To maintain an estimated N_e of 50, a recommended minimum, approximately 5 female bison would have to be introduced every 7 years. To maintain an estimated N_e of 100, the agencies' goal for protecting genetic variability, more than 7 bison would have to be introduced to the population each generation (Table 2). Female bison would be the best candidates for introductions because males have a higher reproductive variance (Shelley and Anderson 1989, Berger 1996). Introduced animals would have to be permanently marked to allow monitoring of their reproductive rates and thus their genetic contribution. Ideally, offspring from the introduced animals would be permanently marked as well.

Shelley and Anderson (1989) suggested that donor populations should be those that are the least similar genetically to the JBH. Genetic distance, however, has not been calculated for most bison herds, and currently the genetic data are inadequate to allow a reasonable estimation of the best sources for new females for the JBH (Berger 1996). A lack of detectable mitochondrial DNA differentiation among bison populations suggests that sources for transplant should not be a cause for great concern (Berger 1996). Nonetheless, based on the available data, all efforts would be made to meet this recommendation within administrative, economic, and logistical constraints. Without information on genetic distance, herds with high heterozygosity indices would be chosen as donor herds.

Impacts On Socio-economic Factors. This alternative represents the lowest level of bison observation opportunity. Fewer recreation opportunities associated with bison would be available than under Alternative 1. The potential for property damage would be lower under this alternative than the others due to reduced bison numbers. Reduced conflicts between bison and humans would mean lower administrative costs for the agencies. Because higher numbers of bison would have to be introduced under this alternative in order to maintain genetic variability, management agencies' costs for importing bison would be higher than they would be under the other alternatives.

The effects on the local economy are likely to be limited under this alternative. Since a substantial increase in bison numbers under Alternative 1 is unlikely to have a major impact on visitation, a moderate reduction in bison numbers is also unlikely to have a major impact. The loss to the local economy from a reduction in administrative costs would depend on the decrease in purchases of local goods, services, and labor.

Herd Size Alternative 3: Herd Size of 200 - 250 (PREFERRED ALTERNATIVE)

Under this alternative the herd would be maintained at a minimum of 200 and potentially up to 250 animals. This alternative is based on a range of numbers that represent a combination of 1) maintaining genetic variability through herd size and induced immigrations (Shelley and Anderson 1989, Berger 1996), 2) available forage estimates on desirable winter ranges, 3) maintaining opportunities for public enjoyment of bison, 4) maintaining the intrinsic ecological value of bison in Jackson Hole, and 5) minimizing risk of disease transmission to domestic livestock. The number of bison in the herd would depend on the ratio of bison wintering on versus off the NER elk supplemental feedlines, using a sliding scale (see discussion under MANAGEMENT ISSUES AND ALTERNATIVES, Management Issue I: Herd Size).

Impacts On Wildlife and Vegetation. Although they would occur at a slightly greater magnitude, the impacts of bison on wildlife and vegetation under this alternative are expected to be essentially the same as under Alternative 2. The increase in numbers from 100 to 200 or 250 is not expected to substantially change any of the effects and no significant impacts are expected. Because of the relative numbers of bison in the herd, this alternative could have negative impacts on predators and carrion eaters compared to Alternatives 1 and 4 but more positive impacts compared to Alternative 2.

Impacts On Endangered Species. By providing for a larger herd size (i.e. more available prey and carrion) than Alternative 2, this alternative would represent a higher potential for benefit to bald eagles, grizzly bears, and gray wolves in the future. Compared to Alternative 1, this alternative would reduce the amount of potential prey and carrion available to these species. No effect of this alternative on peregrine falcons or whooping cranes is anticipated.

Impacts On Visual Resources and Recreation. Because bison distribution and movement patterns have remained much the same as the population has grown from 100 to approximately 250 animals, observability has changed little. Thus, recreational viewing opportunities under this alternative would not differ significantly from Alternative 2. Viewing opportunities would be fewer than under Alternative 1. The potential for bison-recreationist conflicts would be low and would not be a significant management concern. Temporary area closures would probably not be necessary, although "bison jams" would probably occur regularly. The impacts of bison on overall Park vegetation would be minor and would not detract from the natural scene.

Impacts on Disease Management. This alternative would present a threat of disease transmission from bison to domestic livestock that is greater than Alternative 2 but less than Alternatives 1 or 4. These comparisons are based on the assumption that, while disease prevalence is not expected to change with herd size, increasing numbers of bison result in an increased probability of disease transmission. Bison distribution and emigration rates have remained relatively constant through increases of the herd from 100 to approximately 250 animals during the last 10 years. Therefore, any increase in transmission probability would result primarily from increased numbers of bison within their current distribution, rather than from large numbers of bison expanding their range and coming into contact with greater numbers of livestock. Since transmission of brucellosis from free-roaming bison to domestic livestock has never been documented, probable transmission rates associated with this herd level are unknown and cannot be estimated.

Disease management alternatives that involve accessing or handling bison would be more difficult, time consuming, and expensive under this alternative than under Alternative 2. For example, during the winter of 1991-92 when approximately 149 bison were known to be in the herd, the average number of bison on feed at the NER was 108 (range = 78-141). The others were widely distributed in the Gros Ventre Hills and would have been difficult to access for handling.

Impacts on Herd Integrity. Under this alternative, N_e would be maintained at approximately 50, a recommended minimum (Shelly and Anderson 1989, Berger 1996), without periodic introductions (Table 2). Consequently, this alternative would maintain a higher level of herd integrity than Alternative 2 and a lower level than Alternatives 1 or 4. To maintain an N_e of 100, the agencies' goal for protecting genetic variability, approximately 3-5 female bison would be introduced from other populations every 7 years (Table 2). Introduced animals would be permanently marked (radio-collared) and their reproductive performance (genetic contribution) monitored by 1) documenting reproductive success or failure, and 2) permanently marking offspring and monitoring their reproductive performance. Donor herds would be selected as discussed under Alternative 2.

Impacts on Socio-economic Factors. Recreation use would be similar to Alternative 2. Bison viewing opportunities would be less than under Alternatives 1 and 4. The potential for property damage would be greater than Alternative 2 and less than Alternatives 1 and 4. Agency costs would be less than under Alternatives 1 and 4 and somewhat more than Alternative 2. The impact on the local economy would be similar to Alternative 2.

Herd Size Alternative 4: Herd Size of 350 - 400

Under this alternative the herd would be allowed to grow to and be maintained at approximately 350 - 400 bison. When and if herd reductions were necessary, they would be accomplished by one or more of the herd reduction methods discussed under Management Issue II: Herd Reduction Methods. This alternative was included to allow for the analysis of potential impacts associated with a significantly greater bison presence in the valley than has occurred in recent times.

Impacts on Wildlife and Vegetation. Under this alternative, the impacts of bison on wildlife and vegetation potentially would be greater than under Alternatives 2 and 3 and less than under Alternative 1. The potential impacts of bison on elk discussed under Alternative 1 would occur at a greater level than either Alternatives 2 or 3 but, for the most part, would probably not be significant. One exception to this generality would be the effect of bison on elk during winter. If bison continued to frequent the NER in winter, less natural forage would be available for elk on their wintering grounds, which would necessitate extending the period of supplemental feeding and/or a reduction in elk numbers. Considering that winter range is limiting for the Jackson elk herd, and that the NER was established specifically for elk winter range, some constituents could view these impacts as significant. Impacts on other species of ungulates would probably be negligible.

The potential for large numbers of bison having beneficial effects on other wildlife species, as discussed under Alternative 1, would be greater than under all alternatives except Alternative 1.

The potential impacts of bison on vegetation, as discussed under Alternative 1, would be higher than all of the alternatives except Alternative 1. At this herd level, localized areas of overgrazing, wallowing, and rubbing could occur, which could cause changes in local plant communities as discussed under Alternative 1.

Because higher numbers of bison would be present under this alternative, the potential for positive benefits to predators and carrion eaters would be greater under this alternative than under Alternatives 2 or 3, but less than under Alternative 1.

In summary, a herd size of 350-400 bison could be expected to have some impacts on vegetation in relatively small, localized areas, some predators and carrion eaters would benefit, and competition for forage with elk would be increased. None of these impacts are expected to be significant, with the possible exception of impacts associated with high numbers of bison on the NER.

Impacts On Endangered Species. The impacts on endangered species would be the same as discussed under Alternative 1, except that they would occur at a smaller scale because of lower numbers of bison present. None of the impacts would be significant.

Impacts On Visual Resources and Recreation. As the herd increased from its current size to 350-400, bison would probably become visible more often and in more areas, positively affecting the natural scene. Non-consumptive recreation opportunities associated with bison such as viewing and photographing would increase. Some localized areas of overgrazing, wallowing, and associated erosion could detract from visual resources. If bison distribution expanded, a greater potential for recreationist-bison conflicts would exist, especially during the summer. Likely areas for range expansion would include Jenny Lake, the Oxbow, Colter Bay, and the Triangle X dude ranch, which are all popular visitor areas. On the NER, greater numbers of bison would increase the potential for conflicts between bison and visitors along the Refuge road. Bison could represent a threat to human safety in these and other areas.

Impacts On Disease Management. Although there is some evidence in cattle that larger herd sizes have higher disease prevalence (Crawford et al. 1990), for purposes of this analysis it is assumed that disease prevalence will not change significantly as the bison population increases in size. This alternative may increase the potential of disease transmission from bison to livestock over time. Increased risk would be due to higher numbers of potential transmitters within current ranges as well as the possibility of higher numbers in new, expanded ranges. If ranges did expand, the probability of interaction with livestock would increase. Areas of concern for range expansion in calving season (when brucellosis transmission is most likely) would include the Gros Ventre pasture and Wyoming State school section 36 in GTNP where cattle are authorized to graze during spring. A greater potential for bison to wander onto private lands where cattle are wintered could also increase the risk of disease transmission. Because transmission of brucellosis from free-roaming bison to domestic livestock has never been documented, probable transmission rates associated with different herd levels are unknown and cannot be estimated. Since it is reasonable, however, to expect the probability of disease transmission to increase with increasing numbers of bison, this alternative would represent a potential disease risk to domestic livestock that is greater than all of the alternatives except Alternative 1.

Under this alternative, disease management alternatives that involve accessing or handling all the bison in the herd (i.e. trap and slaughter/transport; vaccinate) would be more difficult than with smaller herd sizes. As the herd level increased, the potential for bison to stray from or consistently use areas outside of those used by the majority of the herd would increase. More bison could winter and summer away from traditional use areas. Consequently, containing the entire herd at one time for handling and/or vaccinating would be more difficult.

Impacts On Herd Integrity (genetics). This alternative would benefit herd integrity more than Alternatives 2 and 3. As the number of animals in the herd increased from its present size to 350-400, the effective population would also increase. A population of 400 would have an estimated N_e of 100 (Table 2), the agencies' goal for protecting genetic variability, without periodic introductions of bison from other populations. If the population was managed at the lower end of the range (350), approximately 1 female bison would have to be introduced from another population every 7 years (Table 2). The reproductive performance of introduced bison would be documented as explained under Alternative 3.

Impacts On Socio-economic Factors. Few socio-economic impacts would be expected under this alternative. The larger herd size would increase recreation opportunities associated with bison in the area. A slightly higher potential for property damage would exist under this alternative, because the larger herd size would represent a greater threat to domestic livestock and other private property. The administrative costs to the management agencies would also be higher under this alternative due to increased monitoring costs and the potential for increased conflicts among bison, livestock, and humans. Annual reductions to control the herd's size, and associated administrative costs, would be higher than under the other herd size alternatives.

MANAGEMENT ISSUE II: HERD REDUCTION METHODS

This section discusses impacts associated with maintaining a population objective through a variety of herd reduction alternatives. General herd reduction protocols that apply to all alternatives, including the numbers, age, and sex of animals removed annually, are discussed in the Management Issues and Alternatives section under Management Issue II: Herd Reduction Method Alternatives.

Reduction Alternative 1: Sterilization or Contraception

Under this alternative the JBH population size would be controlled by fertility reduction through sterilization or reversible contraception using steroids or immunocontraceptives. The number of animals that would have to be treated would depend on the selected target herd size and the size of the bison population at the initiation of treatment. No treatment would be necessary if the "No Action" alternative for herd size is selected.

Impacts on Wildlife and Vegetation. Any proposed sterilization program to limit the population size for this herd would have only limited impacts on other species of wildlife. No direct impacts to other wildlife are anticipated. Fewer bison calves would be born, possibly decreasing prey and carrion available to coyotes, ravens, magpies, and other species. If chemical contraceptives were available for bison, one would be selected that could not be passed through the food chain, in order to avoid potential harmful effects on non-target wildlife.

The construction of holding facilities, if such were deemed necessary for treating bison, could displace other species of wildlife from the area where the facilities were placed. If a contraception program were selected that required repeated trapping and handling, impacts on the free-ranging nature of the bison population could be significant. Other wildlife could be temporarily disrupted while herding and trapping operations were occurring.

Impacts on Endangered Species. Sterilization of bison would not have any direct negative impacts on endangered species. Fewer bison calves would be born if a sterilization or contraception program were implemented, possibly decreasing the amount of prey and carrion available to gray wolves, grizzly bears, and bald eagles.

The use of steroid contraceptives that could be passed through the food chain would be avoided in order to prevent potential harmful effects on endangered species.

Impacts on Visual Resources and Recreation. The use of sterilization or contraception to control herd size would have potential impacts on both visual and recreational resources. If the annual production of bison calves were reduced or eliminated, the aesthetic value some visitors and residents derive from viewing this herd would decrease. If the size of the bison population were controlled through fertility reduction instead of culling, the opportunity to hunt bison would be decreased or eliminated.

Facilities constructed to capture and hold bison for sterilization or treatment with contraceptives could detract from visual resources if constructed in areas frequented by the public. If a contraceptive method were chosen that required repeated trapping and handling of the bison, the free-ranging nature of the herd could be compromised. Some constituents might question the humaneness and appropriateness of such treatments.

Impacts On Disease Management. Because the greatest chance of shedding the Brucella abortus bacteria occurs during expulsion of infected birth products, sterilization or contraception of females would reduce the likelihood of transmission of brucellosis from bison to other wildlife species or to domestic livestock. Since transmission of brucellosis from free-ranging bison to domestic livestock has never been documented, the degree to which risk of transmission would be decreased by sterilization or contraception is unknown and cannot be estimated.

If a contraception or sterilization alternative were chosen that required trapping and handling of bison, either on a one-time or repeated basis, holding pens and other facilities could be used as well for testing, vaccination, and other disease management activities.

Impacts on Herd Integrity (genetics). If most of the adults of either sex were sterilized to control population size, genetic stagnation and increased rates of inbreeding would result. The population's ability to recover from disease or extreme environmental conditions could also be reduced. Because males vary more than females in their reproductive contribution, removing some (but not all) successfully breeding males could serve to equalize the contributions of less successful breeders and could increase rather than decrease N_e (Berger 1996). Removing a large number of potentially breeding bison of either sex, however, would decrease N_e. Ideally, to maximize N_e, an even sex ratio of breeders should be maintained in the population (Berger 1996).

Using reversible contraception instead of permanent sterilization could reduce the genetic impacts of a fertility reduction program. Treating an animal with a reversible contraceptive would not preclude its making a genetic contribution to the population at a future time when the contraceptive treatment is terminated. Nevertheless, application of a reversible contraceptive to a large percentage of the population over the long term would still decrease N_e.

Impacts On Socio-economic Factors. Because biochemical contraceptive agents for bison have not been developed or tested, the potential costs of using such agents cannot be estimated at this time. Costs would depend on the number of animals to be treated, construction of holding facilities if needed, the cost of the contraceptive itself, the costs of delivery (capture, aerial darting, etc.), surgical supplies and drugs, and veterinary services. Costs would increase if repeated inoculations were necessary or if the treatment was of short duration. If fertility control were used in combination with periodic culling, additional costs would depend on the number of excess animals to be culled and the frequency of culling.

The costs of surgical sterilization can only be estimated and would vary greatly depending on the final population objective. Facilities would have to be constructed to surgically treat animals. The construction of holding facilities, corrals and squeeze chutes for sterilization would cost at least $40,000-50,000 (1991 dollars) to handle current numbers of animals in the herd (J. Malcolm, National Bison Range, pers. comm. 1991). Additional costs would include veterinarian fees to perform the surgery. Costs associated with flank removal of ovaries would include veterinarian fees of approximately $50/hour or $400/day while surgical and drug costs would be approximately $100-200/animal (Ken Griggs DVM, Teton Veterinary Clinic, and T. Thorne, WGFD, pers. comm. 1991). Veterinarian costs would probably range from $220 to $250 (1991 dollars) per animal. If local veterinarians are used to perform the sterilizations, the local economy would benefit.

Although the quality of recreational use under this alternative would be reduced due to the loss of aesthetic values from viewing young bison calves, the quantity of bison viewing would be unchanged, and visitor expenditures in the local economy would be unlikely to change significantly.

Reduction Alternative 2: Agency Reductions

Under this alternative, personnel from the Wyoming Game and Fish and the NER would use lethal means (high caliber rifle) to remove animals from the population. Reductions would most likely occur during winter when bison are associated with elk feedlines, but could occur at other times of year. The number of animals that would have to be removed on an annual basis would depend on the population objective. No reduction would be completed under the "No Action" alternative for herd size. The carcasses of culled animals would be donated or sold to Native American tribes, instructional institutions, or private groups and individuals, or used for research.

Impacts On Wildlife and Vegetation. Some disturbance to elk on the NER would occur during the reduction activities, but this would be limited to temporary displacement of elk from the feeding area where reductions would occur. Gut piles left at reduction sites would provide a small benefit to scavengers.

Impacts On Endangered Species. No impacts are anticipated. Gut piles may provide a food source for bald eagles, grizzly bears, and gray wolves.

Impacts On Visual Resources and Recreation. No impacts on visual or recreational resources are expected. The culls would likely take place during the late fall, winter, or early spring while animals are concentrated on the NER in areas closed to the public. The bison are isolated at this time of year and not available for public viewing.

The quality of recreation use under this alternative would be higher than Alternative 1 since recreationists would have the opportunity to view young bison calves.

Impacts On Disease Management. Gut piles containing infected uteri, placentae, uterine fluids and/or fetuses could be a source of infection to other bison or elk. The effect on herd infection prevalence is unknown. Assuming reductions are always done in areas not open to cattle, no increased risk to livestock is expected.

Impacts On Herd Integrity (genetics). Agency reductions would permit agency personnel to select animals for annual culling. In order to maximize N_e, the effective population size, and thus to maximize genetic variability over time, an even sex ratio of breeders should be maintained in the population (Berger 1996). Under this alternative managers would have the opportunity to regulate age and sex ratios of the bison remaining in the herd by selecting animals to be harvested, thereby helping to ensure genetic integrity through time.

Impacts On Socio-economic Factors. The costs associated with this reduction alternative would be limited to agency personnel time and equipment. Approximately 12 personnel from the WGFD and the NER would be needed to carry out reductions. The time required for the reduction would vary from 2 days to maintain about 100 animals to perhaps 10 days to maintain 350-400 animals. Some of the agency costs could be offset by selling the carcasses. The costs to the agencies of this alternative are much less than Alternative 1, both in the short and long term.

Because there are ample opportunities to view bison calves in Yellowstone National Park, the presence of bison calves in the local herd would not significantly affect visitor expenditures in the local economy under this alternative. Benefits to the local economy from agency expenditures would be less than under Alternative 1. The possibility for brucellosis transmission to domestic livestock would be greater than under Alternative 1 because more natural reproduction would be occurring in the area.

Reduction Alternative 3: Public Hunt Reduction

Under this alternative, hunters licensed by the Wyoming Game and Fish Department would cull bison selected for removal by WGFD personnel. Agency personnel would accompany hunters.

Impacts On Wildlife And Vegetation. Impacts would be limited to possible displacement of elk from areas of the NER where bison reductions occur. Depending on the timing of the reduction, this could cause higher numbers of free-ranging elk to concentrate on the southern portion of the NER and reduced use of forage on the northern portion. Gut piles left at reduction sites would provide a small benefit to scavengers.

Impacts On Endangered Species. No impacts are anticipated. Gut piles may provide a food source for bald eagles, grizzly bears, and gray wolves.

Impacts On Visual Resources and Recreation. No impacts to visual resources are expected. Opportunities to view bison calves would probably be higher under this alternative than under Alternative 1. Hunting opportunities would be greater under this alternative than under all other alternatives. Past public hunts have been very popular with the hunting publics, and response in favor of public hunting on the 1994 draft plan was high (see Appendix IV, Summary of Public Response to 1994 Draft Plan).

Impacts On Disease Management. Impacts would be similar to Alternative 2.

Impacts on Herd Integrity (genetics). Because agency personnel would accompany hunters and select the animals to be culled, appropriate age and sex ratios of animals in the herd could be effectively maintained. This would help ensure the long term genetic variability and viability of the herd.

Impacts On Socio-economic Factors. The use of hunting as a reduction method for the JBH has drawn a great deal of public attention, both positive and negative, in the past. Over 3,000 applications were received during the first drawing for 16 permits in 1990. Fees charged for bison hunts in other parts of the country indicate that the opportunity to hunt bison is worth several thousand dollars per bison to hunters. Bison hunting has been controversial in the past and some constituents are philosophically opposed to a public bison hunt.
Because the hunt would take place during fall and winter on parts of the NER not generally used by the public, nonconsumptive recreational opportunities (viewing, photographing), which usually take place in spring, summer, and fall in GTNP, would not be seriously affected.

The potential for transmission of brucellosis to domestic livestock under this alternative could be greater than under Alternative 1 because more natural reproduction would be occurring in the area. Risk of disease transmission would be comparable to Alternative 2. Agency management costs would be higher than Alternative 2.

Expenditures by bison hunters during their stay in the area would provide a benefit to the local economy. Direct spending could provide from $9,000 to over $43,000 to the local economy depending on the number of permits available (see Appendix IX). In addition, license fee revenue of from $7,800 to over $35,600 would be generated. Finally, the local economy would gain if part of the expenditures associated with administering the hunt were spent in the area. Future agency costs associated with this alternative would depend on the final population objective.

Reduction Alternative 4: Trap and Transport to Quarantine

Under this alternative the desired population objective would be maintained by trapping and transporting disease-free animals to a quarantine facility (see discussion under Management Issues and Alternatives, Management Issue II, Reduction Alternative 4 for details and quarantine facility protocols). After being declared disease-free at the quarantine facility, bison would be donated or sold and could be transported live to other locations. Bison that tested positive for brucellosis during trapping activities would be marked and released. If necessary to maintain equal sex ratios and desired age class ratios, some disease-free animals would be retained in the population.

Impacts On Wildlife and Vegetation. This alternative would have some negative impacts to other wildlife, primarily elk. This impact would be confined to the immediate vicinity of the trapping facilities. If the trapping facilities and holding pasture were located on the NER, their presence would reduce the amount of vegetation that would be available to elk when they arrive on the NER every fall. The amount of vegetation that would be lost would depend on the size of the facilities to handle the bison. Current migration corridors used by elk to get to the southern portions of the Refuge could be altered or disrupted if the trapping and holding facilities were located in certain locations north of Flat Creek near Long Hollow on the NER.

Bison held and transported to quarantine under this alternative would be subject to less than desirable conditions and some injuries would occur. Free-ranging, wild bison are not accustomed to being confined in the small spaces that trapping, holding and transporting require. Excited behavior among bison in such conditions often results in animals being gored, and serious or lethal injuries can occur. The humaneness of such practices may be questionable.

Impacts On Endangered Species. No impacts are anticipated.

Impacts On Visual Resources and Recreation. This alternative could have some negative impacts to both visual resources and recreation. The trap, processing area, and enclosed pasture would have negative visual impacts, unless they were located in areas that are not visible to the public. There are only a few areas on the NER where this type of facility could be located out of sight of possible viewing. If sited on the NER, the facility would probably be located close to the existing areas used by bison, primarily at the mouth of Long Hollow or along Flat Creek. Should the facilities be located at this location and migration patterns of elk affected, the ability of hunters to pursue and harvest elk may be affected. Trapping bison would have to be limited to times when the elk hunting season is not open to avoid possible safety concerns to personnel handling bison.

Non-consumptive recreation opportunities associated with bison such as viewing and photographing would not be affected. Opportunities to view bison calves would probably be higher under this alternative than under Alternative 1. Public hunting opportunities that would be available under Alternative 3 would not be available under this alternative.

Impacts On Disease Management. This alternative could aid in conducting research on bison diseases in this herd, as facilities would be in place to handle individual animals. The placement of this type of facility may increase the potential for pressure to implement a test and slaughter disease management program. This alternative would increase the disease prevalence in the herd because 1) only disease-free animals would be candidates for removal, which would increase the proportion of seropositive bison in the herd, and 2) some bison that are genetically resistant to brucellosis (J. Templeton, Texas A&M University, pers. comm. 1995) would be removed from the population, thus precluding their opportunity to pass genes for brucellosis resistance on to future generations. The potential for brucellosis transmission to domestic livestock would be greater than under Alternatives 1, 2 and 3 because seroprevalence in the herd would increase over time as disease-free bison were removed.

Impacts On Herd Integrity (genetics). Same as Alternative 2.

Impacts On Socio-economic Factors. A temporary trapping and handling facility would be used to implement this alternative. The facility would include drift fences to guide bison into capture and holding pens, which would be connected to a handling facility consisting of holding corrals, a crowding tub, alleys, and a squeeze chute. Initial capital costs for the materials would likely exceed $80,000 (J. Mack, Yellowstone National Park, pers. comm. 1996). Other costs would include construction costs, wages for additional personnel needed to complete the trapping and processing, costs for feeding and watering bison, and annual maintenance and repair costs for the facility. Costs of holding bison in a distant quarantine facility for 6 to 48 months or longer (see discussion under Management Issue II: Herd Reduction Method Alternatives) are not included here but would be substantial.

Because no bison hunting would take place under this alternative, the local economy would receive none of the benefits from expenditures by bison hunters discussed under Alternative 3.

Reduction Alternative 5: Native American Hunt Reduction

Under this alternative Native Americans would be allowed to cull bison at the same rates as under Alternatives 2 and 3. WGFD personnel would accompany Native Americans to assure that desired sex and age ratios are maintained in the bison population by culling only selected animals.

Impacts On Wildlife and Vegetation. Same as Alternative 3.

Impacts On Endangered Species. No impacts are anticipated.

Impacts On Visual Resources and Recreation. No impacts to visual resources are expected. Opportunities to view bison calves would probably be higher under this alternative than under Alternative 1. Public hunting opportunities that would be available under Alternative 3 would not be available under this alternative.

Impacts On Disease Management. No impacts are anticipated. Risk of brucellosis transmission from bison to livestock would be greater than Alternative 1, less than Alternative 4, and similar to Alternatives 2, 3, and 7.

Impacts On Herd Integrity (genetics). Under this alternative, as under Alternatives 2 and 3, managers would have the opportunity to regulate age and sex ratios of the bison remaining in the herd by selecting animals to be harvested, thereby helping to ensure genetic integrity through time.

Impacts On Socio-economic Factors. Potential impacts would be similar to Alternatives 2 and 3, with the following exceptions. It has not been determined if a fee would be assessed to the tribes for each animal culled. If no fee was charged, the potential economic benefits to the Wyoming Game and Fish Department would be eliminated. Possible income to the local community is not expected to change appreciably from Alternative 3 as the same number of animals would be harvested annually. Agency costs would be similar to Alternative 3.

This alternative would benefit Native Americans by providing them the opportunity to hunt bison and to take the carcasses for food and ceremonial purposes.

Reduction Alternative 6: Trap, Test and Slaughter

This alternative would be similar to Alternative 4 except that animals would not be transported out of the herd unit alive. Once animals were trapped, they would be tested for brucellosis and tuberculosis. Animals that test positive for either disease would be destroyed until enough animals were removed to keep the herd at the recommended population objective. Any TB-infected carcasses would be destroyed. Other carcasses could be donated or sold to Native American tribes, other organizations, or individuals.

Impacts On Wildlife and Vegetation. Same as Alternative 4 except that impacts on bison associated with transport would not apply.

Impacts On Endangered Species. No impacts are anticipated.

Impacts On Visual Resources and Recreation. Same as Alternative 4.

Impacts On Disease Management. This alternative would benefit disease management objectives by focusing bison removal on individuals that test positive for brucellosis or tuberculosis. Over time, seroprevalence in the herd could be expected to decrease, especially if bison wintered away from elk feedlines on the NER. As seroprevalence rates decreased over time, the possibility of brucellosis transmission from bison to domestic livestock should decline. The long term effects of this alternative on disease management in the JBH would depend on the rate of interspecific transmission, immigration of seropositive bison from Yellowstone National Park, and duration of Trap, Test and Slaughter management.

Impacts On Herd Integrity (genetics). Same as Alternatives 2-5 and 7.

Impacts On Socio-economic Factors. Socio-economic impacts would be similar to Alternative 4. A trapping, handling, and holding facility would have to be constructed. Under this alternative, bison would be held only long enough to complete testing procedures, remove the necessary reduction quota, and release animals remaining.

Reduction Alternative 7: Combination Public Hunt / Herd Reduction for Native American Use (PREFERRED ALTERNATIVE)

Under this alternative, a public hunt administered by WGFD would be held annually with a small number (5-10, depending on herd size) of hunting licenses being issued. The remainder of bison to be removed from the herd each year would be made available to Native Americans. Agency personnel would accompany tribal members and select which animals would be culled. Tribal members would be responsible for processing and transporting the animals. Most culling would probably occur during winter when bison are on wintering grounds and are easily accessible.

Impacts On Wildlife and Vegetation. Some disturbance to elk on the NER would occur during the reduction activities, but this would be limited to temporary displacement of elk from the feeding area where reductions would occur. The public hunt could also cause temporary displacement of elk. Gut piles left at reduction sites would provide a small benefit to scavengers.

Impacts On Endangered Species. No impacts are anticipated. Gut piles may provide a food source for bald eagles, grizzly bears, and gray wolves.

Impacts On Visual Resources and Recreation. No impacts on visual resources are expected. Opportunities to view bison calves would probably be higher under this alternative than under Alternative 1. Public hunting opportunities would be less under this alternative than under Alternative 3, but the “fair chase” aspect of the public hunt would increase its recreational value.

Impacts On Disease Management. Same as Alternatives 2, 3 and 5.

Impacts On Herd Integrity (genetics). Same as Alternatives 2-6.

Impacts On Socio-economic Factors. The positive economic impacts associated with public hunting of bison would be similar to Alternative 3, but the degree of benefit would be at the low end of the range due to the small number of hunters. This alternative would benefit Native Americans by providing them with bison carcasses for food and other purposes. Agency costs would be somewhat higher than Alternative 2 because of the costs of administering the public hunt, but less than Alternative 3.

MANAGEMENT ISSUE III: WINTER DISTRIBUTION

Winter Distribution Alternative 1: No Action

Under this alternative the JBH would continue to migrate to the NER each fall and spend approximately 6 months (mid-October through mid-April) on the NER. Because of their habituation to pelleted alfalfa, the bison would continue to consume supplemental feed during elk feeding operations, which usually run from mid-January through March.

Impacts on Wildlife and Vegetation. Specific impacts of bison on wildlife and vegetation were previously discussed under the No Action Alternative for Management Issue I: Herd Size. With no changes in current distribution of bison or their behavior, we expect most if not all members of the herd to winter on the NER. Thus for 6-7 months of the year, impacts of bison on other wildlife and vegetation will be limited to the NER.

The species most affected by bison on the NER will be elk. Bison are dominant over elk and displace elk from supplemental feedlines when they feed in the same area. The NER has attempted to mitigate this by feeding bison separately from elk and providing them more than a daily maintenance ration. When the bison herd numbered 60 animals (1983) or less, separate feeding was fairly effective at reducing competition between bison and elk. As the herd has grown, however, the bison have split into more groups, making it difficult to separate them from elk. Bison have the potential to disturb large numbers of elk in the high density Refuge feedground setting. But during the one year that Helprin (1992) studied bison-elk interactions, he found that the effect of bison on elk energy expenditures was low.

Each winter, diminishing availability of winter forage is the impetus for initiation of winter feeding of the Jackson elk herd. Bison compete with elk for standing forage on the Refuge before, during, and after the period of supplemental feeding (the supplemental feeding period has averaged 73 days per year since 1975). Both species are primarily grazers. In a variety of habitats where their food habits have been studied, 85% or more of bison diets consist of grasses and grasslike plants (Kautz and Van Dyne 1978, Van Vuren 1981, Hudson and Frank 1987, Peden et al. 1974, Meagher 1973). Where both grasses and shrubs are available, elk generally prefer grasses in winter and spring. In the Greater Yellowstone Area, winter diets of elk consisted of at least 63% grasses (Constan 1972, Greer et al. 1970, Cole 1969). Grasses constitute more than 85% of diet intake in spring (Nelson and Leege 1982).

About 80% of current annual forage production (95% CI = 19,196 ± 2,062 tons) on the NER from 1985-1995 was herbaceous vegetation (USDI-USFWS 1996). The remainder was annual growth of woody plants. At an average consumption rate of 20 pounds/bison/day (compared to 10 pounds/elk/day (Stoddart and Smith 1955, Nelson and Leege 1982)) a herd of 200 bison removes 2.0 tons of herbaceous forage/day, or 200 tons during the average winter (this figure assumes bison consume no standing forage during the 73 days that they are supplementally fed).

Present numbers of bison probably compete to a very limited degree with other species of wildlife on the NER. Although their dust wallows remove vegetation that may be used as food or cover by a variety of mammalian and avian species, bison wallowing and grazing can increase habitat diversity. Collins and Barber (1985) found that in grassland ecosystems, community diversity is maximized under a natural disturbance regime, including bison grazing and wallowing. Because heavy grazing by bison favors browse and forb species that compose the primary diet of pronghorn antelope, bison may create favorable conditions for pronghorn in grassland ecosystems (England and DeVos 1969). In GTNP, bison and pronghorn use many of the same areas during spring, summer, and fall.

Wallowing by bison can completely remove vegetation from selected areas. When natural revegetation occurs, noxious weeds and other invader species often colonize dust wallows. These can serve as seed dissemination sites for noxious weeds such as spotted knapweed and musk thistle, which are invading the NER. Erosion and associated effects on vegetation near favored watering areas may also occur. The various effects of bison on vegetation would probably be localized.

Rubbing and grooming by bison have damaged the bark of many mature cottonwood trees along Flat Creek. Smaller trees have been broken. These trees are important roost and perch sites for bald and golden eagles, red-tailed, Swainson's, and rough-legged hawks, peregrine falcons, and other birds. Damage caused by bison could reduce the longevity of these trees. In combination with browsing of new cottonwood shoots by elk, this could eventually eliminate this component of the riparian habitat.

In summary, the alternative of continuing to winter the entire JBH on the NER will have the greatest effects on the wintering elk population and its food resource. These effects could be expected to vary with the size of the bison herd and the severity of winters. While plant and animal species diversity may increase locally from bison grazing and wallowing, both could be affected negatively by damage from grooming activities.

Impacts on Endangered Species. Other than the impacts on perch/roost trees noted above, bison have very little impact, positive or negative, on endangered species. Only bald eagles and peregrine falcons regularly use the NER. Bald eagles will scavenge any winter mortalities of bison. Grizzly bears rarely frequent this area, but may scavenge winter mortalities upon emerging from dens in the spring. If wolves eventually return to this area, they may prey on wintering bison. One whooping crane has spent several days during spring on the southern portion of the NER in recent years. This alternative should have no impact on that species.

Impacts on Visual Resources and Recreation. If the bison herd continues to winter on the NER, there will be little if any opportunity for viewing, photography or other recreational pursuits of bison from approximately mid-October through mid-April. The NER has a policy of holding bison north of Flat Creek, to the extent possible, to avoid potential conflicts between bison and visitors to the NER sleigh ride vicinity and pedestrians on the Refuge road. In particular, bison could be a potential threat to the horses of the sleigh ride operations if they are not hazed from the area. Horse gorings by bison have occurred in the past on the NER and elsewhere in Jackson Hole. Currently NER personnel regularly haze bison out of areas used by sleigh ride operators to ensure that bison don't pose a danger to visitors. Bison will continue to be restricted to the McBride elk feeding area, as much as possible, and hazed northward away from visitor facilities, private homes and traffic on the Refuge Road. Thus recreational opportunities will remain limited.

If bison winter on the NER where they have access to supplemental feed, winter mortality will remain minimal. As a result, more animals will need to be culled from the population on an annual basis to hold numbers at a herd size objective than would be necessary if the population experienced higher natural winter mortality. If the selected Herd Reduction Alternative involves hunting, this will contribute to hunting opportunities. Most animals that are culled or harvested from the herd will probably be removed on the NER.

Impacts on Disease Management. The potential for transmission of communicable diseases, such as brucellosis and tuberculosis, increases with concentration of animals during those times when transmission can occur (Thorne 1982, Smith and Roffe 1994). In game ranching situations, where animals are often crowded and fed, diseases are widespread among cervids, including elk (Beatson 1985, Geist 1991, Lanka et al. 1992).

Tuberculosis is not currently a threat to the JBH. Should it spread southward from infected game-ranched elk herds in Montana, it could devastate the JBH and severely impact the Jackson elk herd. Concentration of both species on winter ranges would increase interspecific transmission rates and the number of animals potentially infected. This alternative achieves no significant spatial separation of bison and elk when they are fed in winter. Highly contagious diseases, such as tuberculosis, would readily be transmitted between elk and bison should either species become infected (Dr. T. Roffe, National Biological Service, pers. comm. 1995).

The JBH and Jackson elk herds are presently infected with brucellosis and have been for many years (see Management Issue IV). Winter feeding artificially concentrates the animals and is likely responsible for maintenance of significant seroprevalence levels in elk (Thorne et al. 1991). Bison in the Jackson herd, possibly due to concentration on feedgrounds, have higher seroprevalence rates than brucellosis-infected bison that are not artificially concentrated on feedgrounds (Williams et al. 1993). Because brucellosis is most readily transmitted during the period from mid-pregnancy through birthing, wintering bison on the NER increases exposure rates of bison and elk to contaminated aborted fetuses and reproductive byproducts. Separate wintering areas for bison and elk would greatly reduce the potential for interspecific transmission of the disease. Reducing the extent of artificial feeding would also likely reduce intraspecific exposure rates to Brucella abortus. The current situation in which bison and elk winter on the NER and are supplementally fed together complicates efforts toward disease management.

Other communicable diseases of elk, bison, and domestic bovines that are spread through saliva or airborne droplets, such as pasturellosis, are likewise more readily transmitted when animals are concentrated (Kradel et al. 1969, Carter 1982, Franson and Smith 1988). Furthermore, overcrowding-induced stress can increase susceptibility of animals to virulent strains of Pasturella (Davis et al. 1970) and little can be done to mitigate spread of the disease in crowded situations once an outbreak is underway (Thorne et al. 1982, Roffe et al. 1993).

Parasitic infestations are likewise more readily spread among animals under conditions of crowding. Although the JBH is not known to have serious parasitic infestations, feedground situations provide ideal conditions for intraspecific transmission of psoroptic mites, which cause scabies in elk (Smith 1985a, Lange 1982, Samuel et al. 1991). Other endo- and ectoparasites are more readily transmitted between animals in crowded conditions as well.

In general, artificial concentration of animals provides optimum conditions for spread of pathogens. In some cases, overcrowding may result in the expression of virulence of disease organisms.

Impacts on Herd Integrity. Herd integrity will primarily be a function of herd size and composition. This alternative will have no effect on herd integrity.

Impacts on Socio-economic Factors. Bison are rarely visible to the public while on the NER, including from the elk sleigh rides. Therefore winter-spring recreational activities that might involve this species do not exist. Viewing, photography, and nature study of bison would be restricted to the months of May through October under this alternative.

Winter Distribution Alternative 2: Fence Bison at the Hunter-Talbot Area During Winter

Under this alternative, bison would be seasonally confined to a 330-acre fenced enclosure from October or November until spring green-up in April. They may or may not be supplementally fed depending upon herd size and availability of standing forage within the enclosure. Bison would free-range throughout the remainder of the year. NPS policies do not specifically address fencing as it pertains to wildlife, but fencing is generally contrary to the agency's policies of "managing native animal life as part of the natural ecosystem", and "minimizing human impacts on natural animal population dynamics" (USDI-NPS 1988). Supplemental feeding of native animals is authorized in national parks only for the purpose of restoring or maintaining a threatened or endangered species or a species of concern under certain conditions and criteria (USDI-NPS 1991). Consequently, implementation of this alternative would be dependent upon authorization for an exception to operate outside of currently accepted and practiced guidelines.

Impacts on Wildlife and Vegetation. Impacts on elk wintering on the NER detailed under Alternative 1 would be avoided. Vegetation damage at the Hunter-Talbot site could result from excessive utilization of forage by bison. This could be mitigated by providing an adequate size enclosure and/or supplementally feeding the bison herd. Additional vegetation damage, soil erosion and noxious weed invasion may result from wallowing and trailing within the fenced enclosure.

Irrigation of the Hunter-Talbot area would be resumed under this alternative. This would represent a shift of emphasis and goals for the area from allowing restoration of natural processes to resuming some agricultural practices (irrigation) for the benefit of bison management objectives. While not outside of NPS policy, such practices are not common in national parks and are viewed by some constituents as compromising park values.

Resumption of irrigation on the Hunter-Talbot would impact Ditch Creek, the source for irrigation water, and its associated riparian corridor. Below the point at which water would be diverted from Ditch Creek to the Hunter-Talbot irrigation system (which is near the Teton Science School), water volume in Ditch Creek would be decreased during the irrigation season (June-September). In relatively dry years, the irrigation diversion could take most of the surface water, which would result in a substantial decrease to areas downstream. Flow measurements taken during irrigation showed that on average about 70% of the surface water was diverted for Hunter-Talbot irrigation (GTNP files).

The effects of this diversion on vegetation within the creek corridor have not been studied. Water rights on the Old Mining Ditch, however, which serves the Hunter-Talbot irrigation system, date back to the early 1900s. In addition, other diversion points downstream were used to water the Mormon Row hayfields, and drainage from other ditches originating at the Gros Ventre River spilled into Ditch Creek closer to the Snake River for several decades in the past. Thus the current vegetation structure and composition of the Ditch Creek riparian corridor downstream from the Hunter-Talbot reflect a complex system of past irrigation practices, including those associated with the Hunter-Talbot.

In consideration of the above, it is unlikely that resumption of irrigation at the Hunter-Talbot will result in any noticeable downstream changes in Ditch Creek's riparian vegetation structure or composition, or its wildlife use. On the other hand, potential long-term changes reflecting a higher, more natural moisture regime would be precluded. The significance of potential changes is unknown, but they would be unlikely to occur for more than a short distance downstream because of the high porosity of soil in the Ditch Creek corridor.

The Hunter-Talbot area is not presently a wildlife wintering area. Although moose use the adjacent aspen woodlands, the Ditch Creek riparian zone, and sagebrush/bitterbrush flats, those areas would not be fenced. The enclosure would have some potential to interfere with elk, moose and deer movements, at least initially.

The JBH has been free-ranging since 1969. Because the bison in the herd have never been confined, their behavioral response to confinement is unknown. A potential for individuals to injure themselves or others in the herd would exist.

Impacts on Endangered Species. Bald eagles will scavenge any winter mortalities of bison. If wolves eventually frequent this area and are able to enter the enclosure, they may prey upon wintering bison. They could be more successful in the enclosure than if the bison herd was totally free-ranging. Grizzly bears rarely frequent this area, but may scavenge winter mortalities upon emerging from dens in the spring.

Impacts on Visual Resources and Recreation. Bison would not be readily visible to the public during the months that they are maintained in the enclosure. In terms of viewing opportunity, this would not differ significantly from the current situation, in which bison winter in areas of the NER that are not visible to the public. During spring and summer, the bison herd would free-range across their summer range (primarily in GTNP) as they do now.

The enclosure itself would be located in a part of the Park that receives little public use. It would potentially be visible from viewpoints above the valley floor and would detract from the Park's natural setting.

Impacts on Disease Management. This alternative offers an opportunity to limit the potential for transmission of brucellosis and other infectious diseases between elk and bison. First, the two species would be geographically separated during the winter when both species are concentrated on limited winter ranges. The opportunity for interspecific exposure to aborted fetuses would be greatly diminished. Second, bison could be handled for testing and treatment of disease, if need be, at the Hunter-Talbot enclosure (although additional handling facilities would have to be constructed). In addition, an enclosure could serve as a bison isolation facility if a significant contagious disease, such as tuberculosis, were to infect GYA ungulates.

Because bison would be concentrated within the enclosure, higher levels of seropositivity for brucellosis may be maintained in the herd than would be found in bison that are not artificially concentrated. The potential for intraspecific spread of pathogens among bison would probably increase under this alternative because of the concentration of bison and because confining them in an enclosure may increase stress levels, making the bison more susceptible to disease organisms.

The risk of disease transmission to livestock would occur only during the period when bison and cattle distributions have the potential for overlap in spring and summer on GTNP grazing allotments and trailing areas.

Impacts on Herd Integrity. None anticipated. Herd integrity will primarily be a function of herd size and composition.

Impacts on Socio-economic Factors. Material costs per mile for the bison enclosure would be approximately $7,900 per mile for the net wire fence and $3,300 per mile for the electric fence. Labor costs for installing the fences would be approximately $6,000 for the net wire fence and $4,750 for the electric fence. Combined labor and materials cost would be $29,700 for net wire and $14,744 for electric fencing (Table 8). Costs will vary somewhat with the size of area enclosed (greater initial costs for a larger area; lesser annual costs for a larger area because less or no supplemental feed will be required), the size of the herd, and winter severity.

The cost of rehabilitating the irrigation system on the Hunter-Talbot, which would be necessary to improve water efficiency and forage production, is estimated at $30,000. Additional costs would be incurred from regular irrigating activities and maintenance.

Table 8. A comparison of costs for construction and operation of a bison enclosure in the Hunter-Talbot area within GTNP (1991 dollars). The maximum cost estimate includes costs for haying and feeding, which may or may not occur, depending on herd size and availability of standing forage within the enclosure.

	Max. Cost	Min. Cost
Net Wire Fencing	$29,700	
Electric Fencing		$14,650
Irrigation, 15 June-15 September	$4,050	$4,050
Haying Contract, 230 acres, $15/acre	$3,450	
Feeding, 60 days, 2 hrs/day, $8.50/hr. plus $400 fuel/equipment	$1,400	
Total First Year Costs	$38,600	$18,700
Annual Recurring Costs (first year minus fence cost + $1,000 fence maintenance)	$9,900	$5,050

Opportunities to view bison would be limited to May through September, as under Alternative 1. Bison would be free to leave the enclosure on approximately April 1st when supplemental feeding of elk on the NER ends. This coincides with herbaceous green-up on the NER and Hunter-Talbot areas.

Winter Distribution Alternative 3: Feed Bison at the Hunter-Talbot Area Without Fencing

Under this alternative, the bison herd would be fed in winter at the Hunter-Talbot area. A ration of supplemental feed sufficient to deter the majority of the herd from migrating onto the NER and adjacent private lands would be provided daily. The bison would free-range during much of the day and likely use the Mormon Row-Kelly Hayfields as winter-spring range to a much greater extent than at present. Supplemental feeding of native animals is authorized in national parks only for the purpose of restoring or maintaining a threatened or endangered species or a species of concern under certain conditions and criteria (USDI-NPS 1991). Consequently, implementation of this alternative would depend on authorization for an exception to operate outside of generally accepted and practiced guidelines.

Impacts on Vegetation and Wildlife. Impacts on vegetation noted under Alternative 2 would pertain here as well, but to a lesser degree. Bison would range over a larger area than the enclosure in Alternative 2 would cover. Trampling of vegetation associated with a feeding operation would occur but bison would disperse after feeding over a larger area, reducing forage utilization and potential range damage in the vicinity of feeding operations. Effects on Ditch Creek and its riparian corridor of resuming irrigation of the Hunter-Talbot area would be the same as under Alternative 2.

A wider distribution of bison affords greater opportunity for competition between bison, moose and elk. However, moose are primarily browsers (Knowlton 1960, Houston 1968, Smith 1985b), feeding on bitterbrush (Purshia tridentata), willow (Salix spp.), chokecherry (Prunus virginianus), serviceberry (Amalanchier alnifolia), and aspen (Populus tremuloides) near the Hunter-Talbot. Bison are primarily grazers (Meagher 1973, Peden et al. 1974, Kautz and Van Dyne 1978, Van Vuren 1981). Small numbers of elk winter east of the Hunter-Talbot on the National Forest in the Ditch Creek drainage. Some competition may occur between bison and elk on those Forest lands, but it would be very limited due to supplemental feeding of bison.

On the other hand, elk and moose may be attracted to the hay feeding operations. Although this would be discouraged, it may be unavoidable. Feeding of pelleted hay instead of long hay reduces waste (Thorne and Butler 1976, Smith and Robbins 1984) and the potential for attracting other wildlife. On the NER, bison generally feed on pelleted alfalfa for a short while and then bed near the remaining feed. They feed later in the day again before moving off to free-range on native vegetation. Pelleted hay is sometimes left by the bison and consumed by elk after the bison leave. The same situation would not occur at the Hunter-Talbot because bison would be fed only a maintenance ration. On the NER they are currently fed a larger than maintenance ration to limit displacement of elk from feedlines.

If long hay was fed to the bison, more time would be required to eat it and they may spend less time free-ranging or free-range over a reduced geographic area. The bison would eat the best of a day's provision and leave the least palatable portions on the ground. As a result, some moose or elk could become habituated to the Hunter-Talbot by feeding on leftover long hay.

Impacts on Endangered Species. The impacts associated with this alternative would be similar to Alternative 2, except that predators and scavengers would not have to get into an enclosure to reach the bison.

Impacts on Visual Resources and Recreation. Compared to Alternatives 1 and 2, bison would be more visible during winter and spring as they free-range in the southeastern portion of GTNP or other areas of suitable habitat they may pioneer. This would provide increased opportunities for residents and tourists to view bison and for interpretive exhibits and activities. The extent of the herd's winter distribution, if they were fed a full daily ration, is uncertain.

Under this alternative, any bison reductions would occur on the NER or the BTNF. Some bison would be expected to move onto the NER each year, despite being supplementally fed at the Hunter-Talbot. Bison that wander onto the NER could become candidates for reduction as a means of discouraging bison from using Refuge feedlines and to meet population size and composition objectives.

Impacts on Disease Management. Impacts would depend upon bison behavior, particularly their distribution in and dispersal from the Hunter-Talbot and Mormon Row-Kelly Hayfields vicinity. Daily feeding may establish and reinforce fidelity to the Hunter-Talbot vicinity. If bison remain in that area, potential for interspecific transmission of disease to livestock would be similar to Alternative 2.

If bison leave the Hunter-Talbot area, they would be most likely to move onto the NER, where they have wintered since 1975. If they stray onto private lands to the west or into the Gros Ventre drainage, they could commingle with cattle. To date, bison have not been observed in the Gros Ventre drainage. Wildlife managers speculate, however, that 4 male bison observed and subsequently killed in the Green River drainage migrated through the Gros Ventre to reach the Green River (USDI-Fish and Wildlife Service 1989, USDI-National Park Service 1990). The animals were unmarked and therefore were probably either from the Jackson or Yellowstone Park herds.

The opportunity for intraspecific transmission of brucellosis would be less than under Alternative 2 because bison would be less concentrated during much of each day.
Impacts on Herd Integrity. No impacts are anticipated.

Impacts on Socio-economic Factors. The costs of implementing this alternative would be similar to Alternative 2 minus the costs of enclosure construction and maintenance. Some additional costs may be incurred for interpretive signs and activities and for patrol. Annual costs for supplemental feed will vary with size of the bison herd and winter severity. Negative impacts on private lands should be similar to Alternatives 1 and 2, unless bison stray significant distances beyond the Hunter-Talbot, Mormon Row-Kelly Hayfields, and the NER.

Winter Distribution Alternative 4: Modify Bison Behavior and Winter Distribution Through Baiting (PREFERRED ALTERNATIVE)

Under this alternative, for several years bison would be fed a sub-maintenance daily ration of highly desirable food, such as a mixture of grains and molasses, to habituate them to the Hunter-Talbot vicinity. They would not be confined, and habituation to the Hunter-Talbot area would depend upon their fondness for the chosen bait. The majority of their dietary requirements would be satisfied by grazing on standing forage, some of which would benefit from resumption of irrigation on the Hunter-Talbot. This alternative would not establish a permanent feeding station within GTNP. It represents an experimental attempt to change bison migratory behavior and winter distributions. If after several years this technique is successful at modifying bison migratory behavior and distributions, baiting would gradually be phased out. If progress toward these goals is not evident 5 years after implementation of this management plan, the goal of changing bison wintering distribution will be reevaluated.

Supplemental feeding of native animals is authorized in national parks only for the purpose of restoring or maintaining a threatened or endangered species or a species of concern under certain conditions and criteria (USDI-NPS 1991). Consequently, implementation of this alternative would depend on authorization for an exception to operate outside of generally accepted and practiced guidelines.

Impacts on Vegetation and Wildlife. Under this alternative, bison would be less concentrated than under Alternatives 1, 2 or 3. Consequent vegetation and soil damage would be reduced to the immediate area where bait is distributed. Bison would disperse over a wider area in the vicinity of Hunter-Talbot each day, thus improving distribution of forage utilization. Total forage removed each winter would increase because bait would provide only a percentage of daily intake requirements.

Competition with other grazers, primarily elk, may increase if bison use winter ranges in Ditch and Turpin Creeks on the BTNF. The majority of their anticipated winter range, however (the Hunter-Talbot and Mormon Row-Kelly Hayfields) is not occupied by elk during winter and early spring (Smith and Robbins 1994).

As under Alternatives 2 and 3, competition between bison and other wildlife on the NER would be greatly diminished. It is expected that habituation of bison to winter-spring residency on or near the Hunter-Talbot could take several years. During the interim, declining numbers of bison would winter on the NER (see Herd Reduction alternatives).

Winter mortality of bison is expected to increase and vary with winter severity and duration. This would result in more naturally functioning herd dynamics and reduce the number of bison that must be removed to achieve population objectives. This would also benefit bison population genetics as the least fit animals drop out of the population. Additional carrion and more animals vulnerable to predation will increase the available protein biomass for predators and scavengers.

Bison would free-range across winter range that could support bison and that presently gets little use by other large grazers: the Hunter-Talbot, Mormon Row-Kelly Hayfields and adjacent lands of GTNP and BTNF. Forage utilization rates would likely be highest on the Hunter-Talbot irrigated fields, where the bison would receive bait daily, and decline as use radiates out from this core area.

Under this alternative, the irrigation of hayland at the Hunter-Talbot would represent a shift of emphasis and goals for the area from allowing restoration of natural processes to resuming some agricultural practices (irrigation) for the benefit of bison management objectives. While not outside of NPS policy, such practices are not common in national parks and are viewed by some constituents as compromising park values. The impacts on Ditch Creek (the source for irrigation water) and its associated riparian corridor are described under Winter Distribution Alternative 2.

Impacts on Endangered Species. As winter mortality increases, carrion available to bald eagles and possibly grizzly bears will increase. If wolves use the area, some predation on bison may result.

Impacts on Visual Resources and Recreation. Compared to Alternative 3, and especially compared to Alternatives 1 and 2, bison would be more visible during winter and spring as they free-range in the southeastern portion of GTNP and possibly in additional areas of GTNP. This would provide increased opportunities for residents and tourists to view bison and for interpretive exhibits and activities. As a more naturally functioning population that is much less dependent upon artificial sustenance, the bison herd would probably be more active and observable throughout daylight hours.

Under this alternative, bison reductions could occur on the NER and on the BTNF. We expect some bison to move onto the NER each year, even if the baiting program is highly successful. Some of those animals will be candidates for reduction as a means of discouraging bison from using NER feedlines and to meet herd size and composition objectives.

Impacts on Disease Management. Impacts would be similar to Alternative 3, although effects of concentrating bison would not be as severe as Alternative 3. Seroprevalence is not likely to change significantly simply due to changes in winter distribution as evidenced by the persistence of high seroprevalence rates among bison on Yellowstone Park's Northern Range (Meyer 1992).

If bison were not artificially fed, late-born calves would be less likely to survive to adulthood. An extended bison calving season increases the duration of risk to livestock from exposure to bison brucellosis. If late-born calves did not survive to contribute to the gene pool, genetic links to late birthing might be lost over time, which could shorten the parturition period and gradually lower disease transmission risk.

Impacts on Herd Integrity. No impacts are expected.

Impacts on Socio-economic Factors. The costs of implementing this alternative would be similar to Alternative 3, with reduced costs for purchase of winter feed. Some additional costs may be incurred for interpretive signs and activities. Annual costs for winter baiting would vary with size of the bison herd but not with winter severity. Negative impacts on private lands are expected to be minimal, assuming that Jackson bison become habituated to the chosen bait.

At an estimated 2 hours of labor needed to dispense bait per day ($12.50/hr. for 7 months =$5,250) and $1,600 for fuel and equipment repairs, costs of providing bait would total approximately $6,850 annually. Cost of the feed (e.g. molasses-laced pelleted alfalfa at $135/ton) would total approximately $71/animal (5 lbs/bison/day x 210 days). Thus the total annual cost of this alternative for labor and feed would be approximately $17,500 for 150 bison, $21,050 for 200 bison, and $24,600 for 250 bison.

The cost of rehabilitating the irrigation system on the Hunter-Talbot, which would be necessary to improve water efficiency and forage production, is estimated at $30,000. Additional costs would be incurred from regular irrigating activities and maintenance.

Winter Distribution Alternative 5: Fence Bison at the National Elk Refuge During Winter

Under this alternative, bison would be seasonally confined to a fenced enclosure on the NER during winter. They may or may not be supplementally fed depending upon herd size, availability of standing forage within the enclosure, and size of the enclosure. Bison would free-range throughout the remainder of the year. U.S. Fish and Wildlife Service policy states that bison will be fenced at no refuges besides those four established by Congress early in this century for the perpetuation of bison herds (see INTRODUCTION, Agency Policies and Mandates). If this is determined to be the most ecologically feasible alternative for managing winter distribution of the JBH, however, securing an exemption from the Service's policy would be pursued.

Impacts on Wildlife and Vegetation. Impacts on the NER detailed under Alternative 1 would be limited to the enclosed area. Vegetation damage within the enclosure site could result from excessive utilization of forage by bison. This could be partially mitigated by providing an adequate size enclosure and/or supplementally feeding the bison herd. Additional vegetation damage, soil erosion and noxious weed invasion may result from wallowing and trailing within the fenced enclosure.

Unlike the Hunter-Talbot area, the north end of the Refuge is currently a wintering area for elk (95% CI = 370 $\pm$ 159 elk over the past 5 years), moose, and occasionally mule deer. A fenced bison enclosure would remove forage from availability to the Jackson elk herd. Such an enclosure would not be constructed on the south half of the NER, the Refuge's most productive lands where the elk spend the majority of the winter. The enclosure would be constructed in the Gros Ventre Hills or Gros Ventre riverbottom. A large enclosure may interfere with elk migrations and impact harvest objectives.

The JBH has been free-ranging since 1969. Because the bison have never been confined, their behavioral response to confinement is unknown. A potential for individuals to injure themselves or others in the herd would exist.

Impacts on Endangered Species. Bald eagles will scavenge any winter mortalities of bison, whether the bison are confined or not. If wolves eventually frequent this area and are able to enter the enclosure, they may prey upon wintering bison. They could be more successful in the enclosure than if the bison herd was totally free-ranging. Grizzly bears rarely frequent the NER.

Impacts on Visual Resources and Recreation. Bison would not be visible to the public during the months they are maintained in the enclosure. This is not a change from the current situation, where bison currently winter on parts of the NER that are not visible to the public. During late spring, summer, and early fall the bison herd would free-range across their summer range in GTNP and BTNF as they do now.

Impacts on Disease Management. This alternative is similar to Alternative 2. A difference is that when bison are released from the enclosure, they could come into close association with elk. Later-calving bison and elk would then provide the potential for interspecies transmission of brucellosis, and close association would provide the opportunity for transmission of other pathogens.

The potential for intraspecific spread of pathogens among bison would probably increase under this alternative because of the concentration of bison and because confining them in an enclosure may increase stress levels, making the bison more susceptible to disease organisms.

The risk of disease transmission to livestock would occur only during the period when bison and cattle distributions have the potential for overlap in spring and summer on GTNP grazing allotments and trailing areas.

Impacts on Herd Integrity. No impacts are anticipated.

Impacts on Socio-economic Factors. Costs of implementing this alternative will vary with the size of area enclosed (greater initial costs for a larger area; lesser annual costs for a larger area because less or no supplemental feed will be required), the size of the herd, and winter severity.

Material costs per mile for the bison enclosure, for a single fence, would be approximately $7,900 per mile.

Opportunities to view bison would be limited to April through September or October, as under Alternatives 1 and 2. Bison would be free to leave the enclosure approximately April 1st when supplemental feeding of elk on the NER ends. This coincides with initiation of herbaceous green-up on the NER and GTNP lands to the north.

MANAGEMENT ISSUE IV: DISEASE MANAGEMENT

Disease Management Alternative 1: No Action

Under this alternative, the status quo would be maintained. The risk of disease transmission to livestock would be changed only by factors unrelated to changing the prevalence of disease in bison, such as bison herd size and minimizing the potential for livestock-bison interaction.

Impacts on Vegetation and Wildlife. No new environmental consequences are expected from taking no action to manage diseases, specifically brucellosis. No change is expected in the prevalence of disease in the bison herd, nor the potential for interspecific disease transmission between bison and elk.

Impacts on Endangered Species. No impacts are anticipated.

Impacts on Visual Resources and Recreation. No impacts are anticipated.

Impacts on Disease Management. This alternative requires pursuing no additional efforts to reduce prevalence or transmission of diseases currently harbored by the JBH, nor to minimize the impact of new diseases entering the herd and possibly being transmitted to other wildlife or livestock. Whatever changes occur in the prevalence of disease in the bison herd, or in the potential for interspecific disease transmission between bison, elk, and cattle, will be due to other factors such as herd size and distribution. Bison will continue to undergo some level of abortions due to brucellosis. Prevalence of brucellosis in elk is not expected to change significantly within the next few years.

Impacts on Herd Integrity. No impacts are anticipated.

Impacts on Socio-economic Factors. No impacts are anticipated.

Disease Management Alternative 2: Test and Removal

Under this alternative, the entire JBH would be trapped and tested for brucellosis and all test-positive females would be removed from the population in an effort to establish a brucellosis-free herd. Unlike Reduction Alternative 6 (Trap, Test, and Slaughter), the intent of this alternative is not to reduce the herd size to meet a particular population objective. The intent is solely to establish a disease-free herd. All infected females would be removed from the herd regardless of the size of the remaining disease-free population. Males would not be removed because they are considered epidemiologically unimportant.

Impacts on Wildlife and Vegetation. These procedures would require multiple capture and testing of JBH bison. Bison would be reproductively removed from the herd, by either killing or sterilization. Facilities would have to be constructed for capturing and holding the bison. Depending on timing and the location of the capture site, activities may or may not disturb local wildlife, including elk. Compared to Alternative 1, localized damage to vegetation would be expected in association with capture activities. This damage would become more severe the longer operations continue. The trapping and processing pasture required would reduce the amount of vegetation that would be available to elk. The amount of vegetation that would be lost would depend on the location and size of the facilities to handle the bison. Current migration corridors used by elk to get to the southern portions of the Refuge could be altered or disrupted if the trapping and holding facilities were located in certain locations north of Flat Creek near Long Hollow on the NER.

Free-ranging, wild bison are not accustomed to being confined in the small spaces that trapping and handling require. Excited behavior among bison in such conditions often results in animals being gored, and serious or lethal injuries can occur. The humaneness of such practices may be questionable.

Impacts on Endangered Species. Because the herd would be substantially reduced in size initially, less prey and carrion would be available for grizzly bears, gray wolves, and bald eagles. Additional impacts would occur only to the extent that capture operations may occupy space used by endangered species.

Impacts on Visual Resources and Recreation. This alternative would reduce recreational opportunities. This would be temporary and populations would be expected to return to pre-removal levels at approximately the herd's current annual rate of increase. If test and removal activities were to continue indefinitely, there would be fewer visual and recreational opportunities as new bison became infected and were removed.

The trapping and processing area would have negative visual impacts, unless it was located in areas that are not used by the public. There are only a few areas on the NER where this type of facility could be located out of sight from possible viewing. If the facility is located on the NER, it would probably be close to the existing areas used by bison, primarily at the mouth of Long Hollow or along Flat Creek. If the facility is sited here, it could affect migration patterns of elk and the ability of hunters to pursue and harvest elk. Trapping bison would have to be limited to times when the elk season is not open to avoid possible safety concerns to personnel handling bison.

Impacts on Disease Management. Under this alternative, the JBH could be made brucellosis-free over a relatively short period of time. This would require labor intensive capture, testing and retesting (to confirm screening tests), and slaughter of seropositive animals. Assuming approximately 77% seroprevalence in the herd (males 84%, females 69%) and a 1:1 sex ratio, such a process would remove an estimated 35% of the herd (all seropositive females). Females could either be culled (killed or consigned to slaughter) or sterilized. Sterilized animals would need to be individually marked to evaluate whether sterilization procedures were effective. The culling of females only assumes infected males are epidemiologically unimportant and are left in the herd.

It is likely that culling or sterilization would have to be repeated as seronegative females convert to seropositive. This would remove additional animals from the herd. If the JBH is left in contact with the highly infected NER elk herd, it is likely brucellosis would be transmitted back to the JBH with eventual return to current conditions.

Impacts on Herd Integrity. Herd integrity would be diminished by removing the seropositive females. Their removal would permanently eliminate their genetic material from the herd, further depleting the genetic variability of the JBH. Depending on the herd size, this would require introduction of additional, brucellosis-free bison to offset the potential loss of heterozygosity. In addition, if only females were removed from the population, sex ratios would become skewed, leading to a decline in N_e.

Impacts on Socio-economic Factors. Few or no impacts are expected. The tourism economy may be affected to a small extent by public reaction towards capture and removal operations or by a decrease in viewing opportunities as the herd size is reduced.

Costs of trapping facilities and labor involved would be similar to costs indicated under Alternative 4 for Management Issue II: Herd Reduction Methods.

Disease Management Alternative 3: Vaccinate with Strain 19

Under this alternative, bison would be vaccinated with the only currently available vaccine against brucellosis, strain 19. Bison would either be remotely vaccinated with biobullets or captured and hand vaccinated in traps. If a more effective vaccine is developed for bison, it would immediately be substituted for strain 19. Research toward this end is in progress, but may not be completed for a number of years.

Impacts on Wildlife and Vegetation. Vaccination can be done by remote injection (biobullets) or capture and hand vaccination. Currently an effective oral vaccine is not available. Only minor disturbance to other wildlife and vegetation loss would be expected with remote delivery because the number of bison to be vaccinated in the JBH is small. Capture and hand vaccination would produce impacts similar to test and removal discussed for Alternative 2.

Impacts on Endangered Species. Impacts would be similar to Alternative 2 if bison are trapped. No impacts are anticipated if bison are vaccinated remotely.

Impacts on Visual Resources and Recreation. If trapping and handling facilities are constructed for hand vaccination, impacts would be similar to those for Alternative 2.

Impacts on Disease Management. Based on current scientific data (Davis 1993), strain 19 vaccine is not efficacious for bison calves and it has detrimental effects in pregnant adults. Calfhood vaccination would not be expected to change the current seroprevalence. Strain 19 vaccination has been used in combination with test and slaughter in the eradication of brucellosis in confined and ranched bison herds. No research has been conducted to identify an effective dose of strain 19 in bison.

Vaccination of adult bison with strain 19 induces a high rate of abortion and possible persistent infections, particularly in the first pregnancy following vaccination (see Disease Management Alternative 3 in MANAGEMENT ISSUES AND ALTERNATIVES section for more discussion). Thereafter, vaccination with strain 19 effectively reduces abortion and thereby the potential for transmission. Protection is incomplete, however, and protection against subsequent infection with field strain Brucella is poor. Consequently, adult vaccination could be expected to: a) possibly provide some decrease in disease prevalence, b) cause abortion in most vaccinated and uninfected pregnant females, c) decrease the ability to measure true disease prevalence because the vaccine confuses serologic testing for the disease, d) decrease the ability to measure risk to livestock because of unclear serologic test results (see Appendix VII), e) result in strain 19 shedding into the environment and f) result in some chronic strain 19 infections in vaccinated animals. The effect of strain 19 vaccination on brucellosis-infected pregnant bison is unknown.

Peterson et al. (1991) modelled brucellosis prevalence in the JBH under a variety of disease management scenarios, and proposed that for a vaccination scheme to be effective less than 10% of the herd should test seropositive for the Brucella antibody post-treatment. He concluded that none of 3 vaccination scenarios, which included 1) female calf vaccination, 2) vaccination of all-age females, and 3) testing and removal of seropositive animals combined with vaccination of female calves or all-age females, would achieve a management goal of reducing seropositive bison to less than 10% of the herd. He further stated that the transmission rate must be reduced to considerably less than 5% to reduce the Brucella-seropositive percentage of the JBH to less than 10%. It is unlikely that these goals could be achieved without limiting contact between susceptible bison and infected bison and/or elk (Peterson 1990). If seroprevalence of cow bison in the JBH could be reduced to 10% (as compared to the current 50-60%) a corresponding reduction in the risk of transmission from seropositive female bison to cattle, elk and other bison may be realized.

More effective vaccines would improve the expected results from adult vaccination. Vaccination alone, however, is likely only to lower prevalence of brucellosis and not to eliminate the disease. Blood tests capable of differentiating seropositive tests resulting from strain 19 vaccination from those resulting from field infection are needed to measure changes in herd infection rate. Promising research using c-ELISA tests in elk and bison suggest the ability to differentiate vaccination and field strain titers may soon be possible. Alternative vaccines such as RB51 have the advantage of not reacting on standard serologic tests and thus allowing for continued surveillance for disease prevalence.

Impacts on Herd Integrity. No impact is expected because no animals are removed from the herd. The magnitude of natural abortion rates due to brucellosis and potential vaccine-induced abortion rates are unknown, but the balance of these may affect the herd's rate of increase.

Impacts on Socio-economic Factors. No impact to the community is expected because no animals are removed from the herd. The vaccination project would be relatively inexpensive with this small group of animals if they are vaccinated remotely. Trapping and hand vaccination would require construction of trapping facilities. Trapping operations would be more labor intensive than remote vaccination. Costs of trapping facilities and labor involved would be similar to costs indicated under Alternative 4 for Management Issue II: Herd Reduction Methods.

Disease Management Alternative 4: Depopulate and Re-establish the JBH from Brucellosis-free Stock

Under this alternative the JBH would be destroyed. Certified brucellosis-free bison would be transplanted to Jackson Hole to re-establish the population.

Impacts on Wildlife and Vegetation. The entire bison herd would be destroyed and there would be a temporary loss of bison in the Jackson area. Depending on timing and location, activities may cause disturbance to other wildlife, including elk. A temporary loss of carrion for scavengers would also occur. Minor damage to vegetation could occur through the operation, but this damage would be significantly less than that occurring during a capture and removal operation.

Impacts on Endangered Species. Only minor impacts associated with a temporary loss of prey and carrion to grizzly bears, bald eagles, and possibly gray wolves in the future would occur.

Impacts on Visual Resources and Recreation. Complete loss of bison-associated recreational activities would occur for a period of time between depopulation of the herd and re-stocking. This impact would be temporary and no long-term impacts are expected.

Impacts on Disease Management. This alternative is likely to be similar to Alternative 2 in its ultimate effects, assuming the bison remain in contact with other infected animals. Ways in which Alternative 4 differs from Alternative 2 include: a) fewer initial costs and logistics than for capture and testing, b) a more rapid method to establish brucellosis-free status, c) increased cost and logistics for obtaining replacements, d) possible changes in herd behavior, distribution and movements, which may affect disease prevalence in an unknown manner.

Impacts on Herd Integrity. The entire herd would be destroyed which completely destroys herd integrity and the genetic identity of the existing herd. Replacement at a later time would consider the role of herd size and structure on population genetics and herd integrity, as well as the influence of source herd heterozygosity on viability of the re-established herd.

Impacts on Socio-economic Factors. No major long-term impacts are expected to the community. Short-term economic losses may occur to the extent that tourism is dependent upon the non-consumptive recreational availability of bison. This is expected to be minor. Other social impacts depend on public acceptance of depopulation. Objections to depopulation, even by a minority of people, may result in negative perceptions of bison management and interference with depopulation. Economic impacts depend upon the availability and cost of replacement bison. Current costs for females of breeding age with known brucellosis histories approach $2000 each on the commercial market. Surplus bison would likely be available from other national parks or national wildlife refuges with costs largely associated with capture and transportation.

Disease Management Alternative 5: Minimize the potential for brucellosis transmission between bison, domestic livestock, and other wildlife while working toward elimination of the disease (PREFERRED ALTERNATIVE)

Under this alternative, a variety of management actions would be taken to minimize the potential for disease transmission between bison and domestic livestock. These actions include:

1. increasing spatial and temporal separation of bison and domestic livestock, through delaying grazing allotment turn-on dates or trucking stock to summer allotments in lieu of trailing,
2. attempting to separate bison and brucellosis-infected elk during winter and spring,
3. recommending vaccination of all cattle grazed on federal lands within Jackson Hole,
4. vaccinating bison against brucellosis when an effective vaccine becomes available. The use of modified doses of strain 19 would occur only subsequent to the development of evidence that it is safe and effective in bison, and
5. conducting risk assessments to identify the probability of disease transmission between wildlife and livestock, and using these as the basis for developing more effective brucellosis management programs.

Because of agency mandates and policies, implementing changes in livestock management would depend on voluntary measures by livestock permittees (see discussion under Issues and Alternatives, Disease Management Alternative 5).

Impacts on Wildlife and Vegetation. Similar to Alternative 3.

Impacts on Endangered Species. No impacts are anticipated.

Impacts on Visual Resources and Recreation. No impacts are anticipated.

Impacts on Disease Management. Impacts resulting from separation of bison from elk and from domestic livestock will depend on the success of these efforts. If local ranchers implement the agencies' recommendations regarding trailing, federal allotment turn-on dates, and cattle vaccination, the risk of disease transmission would decline. Further decreasing transmission risk would depend on development and administration of an effective brucellosis vaccine for bison, potentially including modified doses of strain 19 (see Alternative 3, Appendix VII, and other discussions under Disease Management in MANAGEMENT ISSUES AND ALTERNATIVES), and the ability to maintain separation of vaccinated bison from brucellosis-infected elk.

If bison and elk wintered at separate locations and an effective new vaccine (or efficacious protocol for strain 19) is developed and administered to the JBH, the prevalence of brucellosis infection in bison would decrease. As a consequence, the risk of transmission of brucellosis from bison to domestic livestock would be further diminished. The risk would remain, however, of brucellosis transmission from elk to domestic livestock.

Impacts on Herd Integrity. No impact is expected.

Impacts on Socio-economic Factors. Measures recommended to minimize contact between bison and domestic livestock, such as delayed grazing allotment turn-on dates or trucking of stock to summer allotments in lieu of trailing, could result in increased costs to the livestock industry. Costs associated with delivery of new vaccines are unknown, but are expected to be comparable with costs associated with administration of strain 19. Risk of brucellosis infections in domestic livestock, and associated socio-economic impacts, would be reduced.

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GLOSSARY

allele One of several possible forms of a particular gene.

animal unit month (AUM) The forage base required to sustain a cow and her calf for one month.

antibody An immunoprotein that is produced by lymphoid cells, in response to a foreign substance (antigen), with which it specifically reacts.

antigen A foreign substance, usually a protein or polysaccharide, that upon introduction into a vertebrate animal, stimulates an immune response.

biobullet A single dose, biodegradable projectile comprised of an outer methylcellulose casing containing a solid, semi-solid, or liquid product (usually a vaccine or chemical contraceptive), propelled by a compressed-air gun.

biotype A variant strain of a bacterial species, differing in identifiable physiologic characteristics from other biotypes.

challenge To administer antigen to evoke an immunologic response in a previously sensitized individual.

congenital Existing at birth.

cross-reactive agent 1. An antigen that reacts with an antibody formed against a different, similar antigen. 2. An antibody that unites with an antigen other than the one used to stimulate formation of that antibody.

culture The propagation of microorganisms or of living tissue cells in special media conducive to their growth.

culture negative Suggesting absence of an organism, as determined by failure to grow the organism in media conducive to its growth.

culture positive Confirming existence or presence of an organism, as determined by growing the organism in media conducive to its growth.

demographic Referring to the intrinsic factors that contribute to a population's growth or decline: birth, death, immigration, and emigration. The sex ratio of the breeding population and the age structure (the proportion of the population found in each age class) are also considered demographic factors because they contribute to birth and death rates.

effective population size (N_e). A mathemetically derived number, reflecting not just the head-count of a population (census population size) but also patterns of breeding participation, gene flow, and loss of genetic variation. N_e is the size of an ideal population having the same rate of increase in inbreeding as the non-ideal population. N_e is typically smaller than the census population size.

false negative Denoting a test result that incorrectly classifies an animal as NOT having whatever the test is designed to measure. Example: a test result indicating the absence of a disease or microorganism when in fact it is present.

false positive Denoting a test result that incorrectly classifies an animal as HAVING whatever the test is designed to measure. Example: a test result indicating the presence of a disease or microorganism when in fact it is absent.

fitness The relative ability of an organism to survive and transmit its genes to the next generation. Components of fitness include survival, disease resistance, growth and developmental rate, and developmental stability, which are generally associated with heterozygosity.

gene A unit of heredity that occupies a specific position within the chromosome and which by interaction with the internal and external environment controls the development of a trait.

genetic variability The amount of genetic difference among individuals in a population, measured by the number of genes in the population that are polymorphic (having more than one allele), the number of alleles for each polymorphic gene, and the number of genes per individual that are polymorphic.

genotype The genetic constitution, latent or expressed, of an organism, as distinguished from its physical appearance (its phenotype). The sum total of all the genes present in an individual.

herd integrity The genetic integrity of the herd or population; i.e., the state in which heterozygosity, fitness, and viability are maintained.

heterozygosity A measure of the genetic diversity in a population, as measured by the number of heterozygous loci across individuals.

heterozygous The situation in which an individual has two different alleles at a given gene locus.

homozygous The situation in which an individual has two identical alleles at a given gene locus.

hormone An organic compound produced in one part of an organism and transported to other parts where it exerts a profound effect.

immunity Resistance to foreign antigens due to a variety of physiological and biochemical processes.

immunocontraceptive A contraceptive agent that causes an animal to produce antibodies against some protein or peptide involved in reproduction. The antibodies hinder or prevent some aspect of the reproductive process.

inbreeding The mating of closely related individuals.

infection Invasion and multiplication of microorganisms in body tissues.

in vitro Biological processes made to occur experimentally in isolation from the whole organism; literally, "in glass," i.e., in the test tube.

isolate A population that has been obtained by isolation.

isolation (of bacteria) The successive propagation of a growth of bacteria until a pure culture is obtained.

locus The site on a chromosome occupied by a specific gene.

N_e See **effective population size**.

pathogen A disease-producing microorganism.

pathogenic Capable of producing disease.

peptide Two or more amino acids linked together. Molecules made up of a relatively small number of amino acids (2 to about 100) are called peptides, while those formed of a larger number of amino acids are called polypeptides or proteins.

phenotype The observable properties of an organism, produced by the genotype in conjunction with the environment.

population The individuals of a particular species in a particular group or in a definable place.

prevalence (of disease) The number of cases of a disease that are present in a population at one point in time.

reactor An individual that reacts or responds to stimulation.

reagent A substance employed to produce a chemical reaction so as to detect, measure, or produce other substances.

serology 1. The study of the nature, production, and interactions of antibodies and antigens. 2. The use of the *in vitro* reactions of immune sera to measure serum antibody titers. 3. The use of serologic reactions to detect antigens.

seronegative Showing negative results on serological examination; showing a lack of antibody.

seropositive Showing positive results on serological examination; showing a measurable level of antibody. Individuals that show the presence of antibodies to a disease organism may or may not have the disease in question. In most diseases antibodies persist after the infecting agent has left the host.

seroprevalence The proportion of individuals in a population that show positive results on serological examination.

serum (plural: sera) The clear portion of any body fluid. Blood serum is the clear liquid that separates from blood on clotting.

shedding The spread of infectious disease organisms into the environment from an infected individual, via body fluids or tissues.

species Groups of naturally interbreeding populations that are reproductively isolated from other such species.

steroid A lipid belonging to the family of saturated hydrocarbons containing 17 carbon atoms arranged in a system of four fused rings.

strain An intraspecific group of organisms, possessing only one or a few distinctive traits, usually genetically homozygous for those traits, and maintained as an artifical breeding group by humans.

strain 19 The strain of *Brucella abortus* bacteria currently used to vaccinate cattle against brucellosis.

test sensitivity The ability of a test to detect animals positive for a condition for which the test is designed. A highly sensitive test will detect almost all animals with the condition, but some animals without the condition may be incorrectly classified as positive. A test yielding a low number of false negative results is highly sensitive.

test specificity The ability of a test to detect only the condition for which it was designed. A highly specific test provides high assurance that those animals testing positive are positive for the specific condition being tested, but some animals that are positive will not be detected. A test yielding a low number of false positive results is highly specific.

tissue An aggregation of similarly specialized cells united in the performance of a particular function.

tissue culture The maintenance or growth of tissue cells *in vitro* in a way that may allow further differentiation and preservation of cell architecture and/or function.

tissue culture isolation rate Proportion of tissue cultures from which bacteria are successfully isolated.

titer 1. The quantity of a substance required to produce a reaction with a given volume of another substance. 2. The amount of a standard reagent necessary to produce a certain result in a titration.

titration A method of determining the amount of some substance present in a solution by measuring the amount of a reagent which must be added to cause a defined chemical change.

undulant fever Human infection with Brucella.

ungulate A hoofed mammal.

vaccine A suspension of killed or attenuated microorganisms that, when introduced into the body, stimulates an immune response against that microorganism.

viable population A population of sufficient size and genetic variability that it maintains its vigor and its potential for evolutionary adaptation.

zona pellucida (ZP) The outer membrane of the mammalian egg.

APPENDIX I: U.S. FOREST SERVICE AUTHORITIES, OBJECTIVES, POLICIES, AND DIRECTION APPLICABLE TO MANAGEMENT OF THE JACKSON BISON HERD

AUTHORITIES:

1. Fish and Wildlife Coordination Act (72 Stat. 563, U.S.C. 661 et seq.). (FSM 2601.1 - 2)

2. Multiple-Use, Sustained-Yield Act of June 12, 1960 (74 Stat. 125, as amended; 16 U.S.C. 528-531). (FSM 2601.1 - 3)

3. National Environmental Policy Act of January 1, 1970 (83 Stat. 852 as amended; 42 U.S.C. 4321, 4331-4335, 4341-4347). (FSM 2601.1 - 4)

4. Endangered Species Act of December 28, 1973. (83 Stat. 852 as amended; 42 U.S.C. 4321, 4331-4335, 4341-4347). (FSM 2601.1 - 5 and 2670)

5. Forest and Rangeland Renewable Resources Planning Act of 1974, (88 Stat. 476 as amended; U.S.C. 1601-1614). (FSM 2601.1 - 6)

6. National Forest Management Act of 1976 (90 Stat. 2949.; 16 U.S.C. 472a, 476 (note), 500, 513-516, 521b, 528 (note), 576b, 592-594 (note), 1600 (note), 1600-1602, 1604, 1606, 1608-1614). (FSM 2601.1 - 8)

7. Federal Land Policy and Management Act of 1976, (90 Stat. 2743; 43 U.S.C. 1701 (note), 1701, 1802, 1712, 1714-1717, 1732, 1740, 1744, 1745, 1751-1753, 1763-1771, 1781; 7 U.S.C. 1012a; 16U.S.C. 478a 1338a). (FSM 2601.1 - 9)

8. Sikes Act of September 16, 1960 (88 Stat. 1369 as amended; 16 U.S.C. 670a, 670g, 670h, 670o). (FSM 2601.1 - 13)

9. USDA Departmental Regulation 9500-4. "Habitats for all existing native and desired non-native plants, fish, and wildlife species will be managed to maintain at least viable populations of such species. In achieving this objective, habitat must be provided for the number and distribution of reproductive individuals to ensure the continued existence of a species throughout its geographic range." (FSM 2601.2 - (1) and 2670.12)

10. Forest Service Wildlife Regulations. "The regulation at 36 CFR 241.2 emphasizes Forest Service responsibility for determining the extent of wildlife and fish use on National Forest System lands, directs forest officers to cooperate with the States in both the planning and action stages of management, and stipulates that the harvesting of wildlife and fish must conform with State laws." (FSM 2610.1 - 5b)

OBJECTIVES

1. "Maintaining at least viable populations of all native and non-native wildlife, fish, and plants in habitats distributed throughout their geographic range on National Forest System lands (FSM 2602 - 1b)."

2. "To develop and maintain partnerships with the appropriate State agencies to jointly establish and meet wildlife, fish, and threatened, endangered, and sensitive species habitat goals, objectives, and standards." (FSM 2610.2 - 1)

3. "To cooperate with other agencies, conservation organizations, concerned landowners, and individuals in all appropriate aspects of wildlife, fish, and threatened, endangered, and sensitive species habitat management." (FSM 2610.2 - 2)

4. "To provide diverse opportunities for aesthetic, scientific, and consumptive uses of wildlife and fish resources on a sustained-yield basis under applicable Federal and State laws and regulations." (FSM 2640.2)

5. "To protect resources and permitted livestock from animal damage on National Forest System lands and to protect human health and safety." (FSM 2650.2)

6. "Manage National Forest System habitats and activities for threatened and endangered species to achieve recovery objectives so that special protection measures provided under the Endangered Species Act are no longer necessary." (FSM 2670.21)

7. "Develop and implement management practices to ensure that species do not become threatened or endangered because of Forest Service actions." (FSM 2670.22 - 1)

8. "Maintain viable populations of all native and desired non-native wildlife, fish, and plant species in habitats distributed throughout their geographic range on National Forest System lands." (2670.22 - 2)

POLICY

1. "Maintain a partnership with State fish and game agencies in habitat management efforts. Recognize the State wildlife and fish agencies as responsible for the management of animals and the Forest Service as responsible for the management of habitat. Involve other Federal agencies, concerned conservation groups, and individuals in activities affecting wildlife and fish as appropriate." (FSM 2603 - 2)

2. "Recognize the role of the States to manage wildlife and fish populations within their jurisdictions and the responsibility of the Fish and wildlife service to manage fish and wildlife resources within its authority." (FSM 2610.3 - 1)

3. "Recognize the State fish and wildlife agencies as a public agency with management responsibilities for wildlife on National Forests and include them as partners in planning and implementation of activities that affect wildlife and fish." (FSM 2610.3 - 2)

4. "Provide leadership in habitat management on National Forest System lands to meet resource objectives of the Forest Service and its cooperators." (FSM 2610.3 -3)

5. "Provide information to and opportunity for the public to use and enjoy the fish and wildlife resources on National Forest System lands." (FSM 2610.3 - 6)

6. "Publicize wildlife and fishing recreation opportunities to obtain use in balance with resource capability." (FSM 2610.3 - 8)

7. "Evaluate the cumulative effects of proposed management activities on habitat capability for management indicators." (FSM 2620.3 - 3)

8. "Provide a variety of fishing, hunting, trapping, viewing, studying, and photographic opportunities and experiences in cooperation with State fish and wildlife agencies." (FSM 2640.3 - 2)

9. "Conduct animal damage management activities when necessary to accomplish multiple-use objectives. Control animals when they: (1) threaten public health or safety; or (2) cause or threaten to cause damage to threatened, endangered animals or plants, other wildlife, permitted livestock, or other resources, on National Forest System lands or private property." (FSM 2650.3)

10. "Through the biological evaluation process, review actions and programs authorized, funded, or carried out by the Forest Service to determine their potential for effect on threatened and endangered species and species proposed for listing." (FSM 2670.31 - 3)

11. "Assist States in achieving their goals for conservation of endemic species." (FSM 2670.32 - 1)

12. "As part of the National Environmental Policy Act process, review programs and activities, through a biological evaluation, to determine their potential effect on sensitive species." (FSM 2670.32 - 3)

OTHER

1. "State laws and regulations apply on National Forest System lands when not in conflict with Federal laws. The Forest Service cooperates in development and enforcement of these laws because it is responsible for habitat management and for regulating all uses on the National Forests." (FSM 2643.1)

2. "Determining the Need for population control. Determine the need for control by: (1) Evaluating past and potential losses or damage; (2) assessing risk to other resources and humans; and (3) determining compliance with Forest plan management direction. Population control should be closely coordinated with the responsible State agencies." (FSM 2651.1 - 1)

3. "Game and Furbearers. Control damage by game animals and furbearers through hunting or trapping, where practicable, in partnership with the State fish and wildlife agencies, and APHIS where appropriate." (FSM 2651.3)

4. "Nongame species. Control nongame species damage on National Forest System lands in close cooperation with State fish and wildlife agencies, or other involved State or Federal agencies." (FSM 2651.4)

5. "Review all Forest Service planned, funded, executed, or permitted programs and activities for possible effects on endangered, threatened, proposed, or sensitive species. The biological evaluation is the means of conducting the review and of documenting the findings. Document the findings of the biological evaluation in the decision notice. Where the decision notices are not prepared, document the findings in Forest Service files." (FSM 2672.4)

6. Master Memorandum of Understanding, Game and Fish Commission State of Wyoming and US Forest Service, USDA. (FSM 4/77 R-4 Supp 24, 2611.1--54 - 66)

7. "Objective 2.1(a) -- Provide suitable and adequate habitat to support the game and fish populations established by the Wyoming Game and Fish Department, as agreed to by the Forest Service." (LRMP at 114)

8. "Fisheries and Wildlife Prescription -- The Bridger-Teton National Forest provides habitat adequate to meet the needs of dependent fish and wildlife populations, including those of Threatened, Endangered, and Sensitive species." (LRMP at 123)

9. **Primary bison ranges (Figure x)** include Desired Future Conditions 2A, 9A, 10, and 12 while the area where the bison is designated as a game animal by the State of Wyoming include Desired Future Conditions 2B, 3, 6A, 6B, 6C, 7A, 7B, 8, and 9B as well. With the exception of DFC 9A and 9B, less than 1% of the area prescriptions, standards, and guidelines for wildlife at a minimum express a desire to meet Wyoming Game and Fish population objectives, as agreed to by the Bridger-Teton National Forest. (LRMP at 145-246)

10. **Primary bison ranges** and those areas where the bison is designated as a game animal are found in Management areas 42, 43, 44, 45, 46, 61, 62, 71, Teton Wilderness, and Gros Ventre Wilderness. There are no additional standards and guidelines in the Management Areas with respect to wildlife that are associated with bison.

APPENDIX II: PUBLIC RESPONSE TO 1987 BISON PLAN AND 1991 SCOPING STATEMENT

Management Concerns/Alternatives	Number of Responses 1987 Bison Plan	Number of Responses 1991 Scoping Statement
Species Diversity	6	
Brucellosis	14	6
Human Safety	3	3
Private Property Losses	3	3
1987 plan Alternative A (No Action)	2	1
1987 plan Alternative D (Preferred - 50 Animals)	10	1
No Bison on NER	3	2
Maintain Herd in GTNP Year Round	9	3
How Many Can GTNP Support?	5	3
Separate Bison from Feed	3	1
Feed Bison Separately from Elk	2	1
Fenced-In Bison Herd	1	
New Funding Sources for Management	10	
Bison as Source of Management Funds	5	
Impact on Soils, Water, Vegetation		3
Accommodate Bison on NER		1
Coexistence with Other Wildlife Populations		1
Numbers of Bison		
Zero-50 Bison	1	
About 100 Bison	7	
About 150 Bison		3
Several Hundred	4	
Self-sustaining Population		3
Genetic Concerns	35	4
Reduction Methods		
Sport Hunting	9	5
Trap & Transplant	9	2
By Agency Personnel	6	2
Not by Killing	9	1
No Sport Hunting	3	
Not by Agency Personnel	6	1
No Reduction at This Time	6	
No Reduction at All	2	1
By Wolf Predation	1	
No Trapping & Transplanting	1	1
By Sterilization	4	2
By Cultural Groups		3
Requests for Bison		
Want Bison Dead or Alive	3	
Want Bison Dead - Meat	3	
Want Bison Alive	2	
American Indian Letter	7	
Want Expanded/Modified EA	27	
Want More Studies	8	2
Want More Public Education		1

NEWS RELEASE u.s. department of the interior

national park service

FOR IMMEDIATE RELEASE
5/16/91

Marshall A. Gingery
Assistant Superintendent
Science & Resource Management
307-733-2880

JACKSON BISON MANAGEMENT PLAN SCOPING STATEMENT

The National Park Service (Grand Teton National Park) and U.S. Fish and Wildlife Service (National Elk Refuge), in conjunction with the Wyoming Game and Fish Department and U.S. Forest Service (Bridger-Teton National Forest), are in the process of developing a long term management plan for the Jackson Bison herd.

The interagency management team has identified several issues to be addressed in the final plan, including:

1. Population Size
2. Socio-economic values of bison
3. Genetic concerns
4. Potential for disease transmission to livestock
5. Methods of herd control
6. Winter Distribution

The Jackson bison herd has continued to increase from the original 14 animals that were allowed to roam free in 1968. A herd objective of 50 animals was established by the Wyoming Game and Fish Department in 1985. In 1988, an interim management plan was adopted by the cooperating agencies that set a herd objective of 90-110 animals. That objective has been maintained to date by using agency reductions and a public hunting program to control numbers.

As part of the current planning process, a number of herd sizes are being considered: 50, the 1985 herd objective; 90-110, the current herd objective; 150, the minimum number needed to alleviate genetic concerns; and unconstrained population growth.

In addition to agency reductions and public hunting, other methods of herd control are being considered, including: sterilization, trapping and transplanting, and culling diseased animals.

The agencies are accepting public comments until June 15, 1991. Comments should be directed to the Interagency Bison Management Team, care of Marshall Gingery, Assistant Superintendent, or Steven Cain, Wildlife Biologist, Grand Teton National Park, P.O. Box 170, Moose, WY 83012 (phone: 307-733-2880).

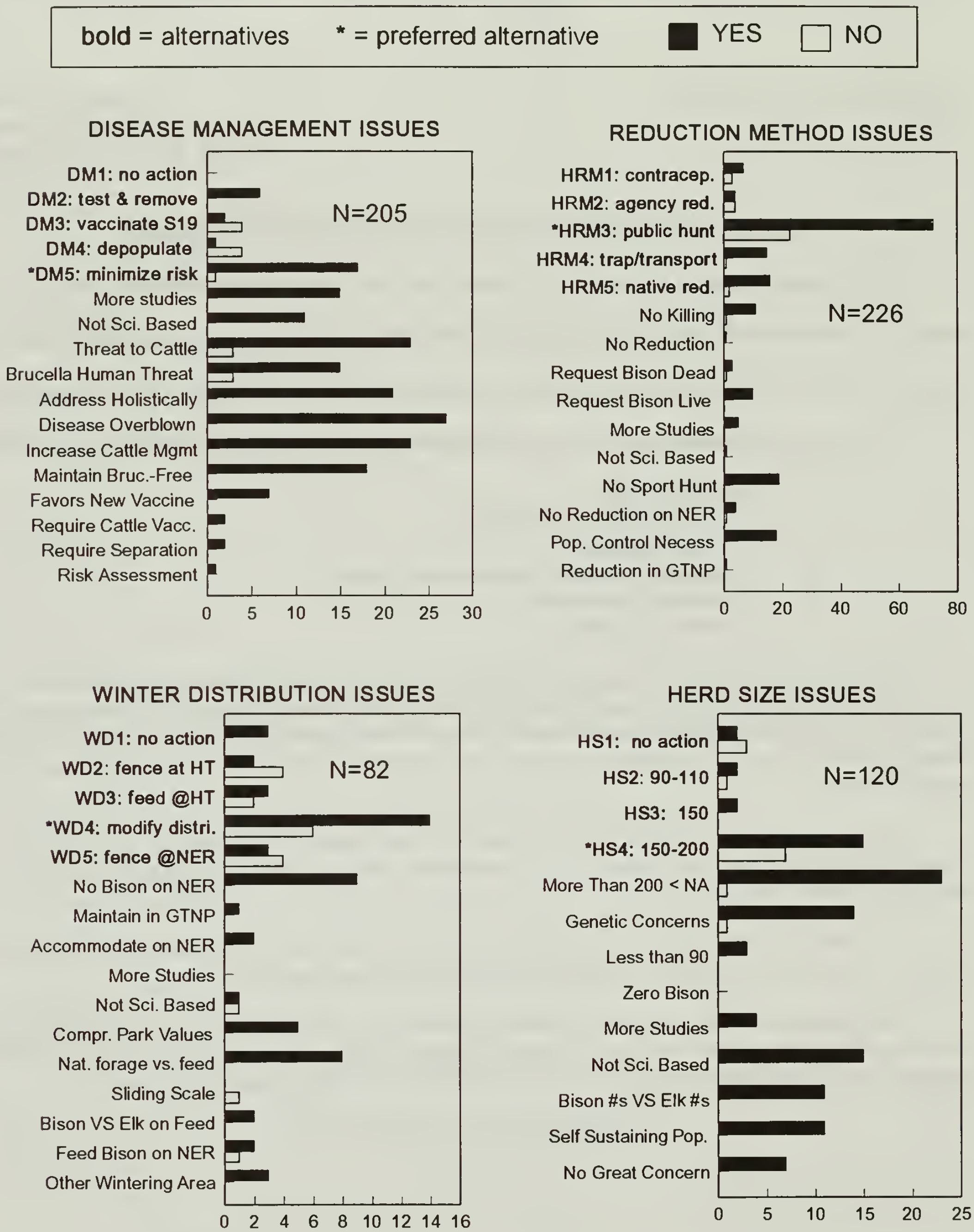
COMMENTS DUE BY JUNE 15, 1991

-NPS-

Grand Teton National Park · P.O. Drawer 170 · Moose, Wyoming 83012

APPENDIX IV: SUMMARY OF PUBLIC RESPONSE TO 1994 DRAFT PLAN

1994 DRAFT BISON PLAN COMMENTS



APPENDIX V: CARRYING CAPACITY OF THE HUNTER-TALBOT AREA

Carrying Capacity - No Haying

The following estimates of forage availability and animal unit months were derived for 330 acres of the Hunter-Talbot area for 1991, the last year that any of the Hunter-Talbot was irrigated. These estimates assume daily intake rates of 20 pounds/animal/day for bison (Stoddart and Smith 1955); forage utilization rates of 50% to not exceed proper use (Ibid.); 1.65 tons/acre of graminoid forage production measured on non-irrigated haylands and 1.35 tons of graminoid and alfalfa production measured on irrigated haylands; and all forage is left standing.

Acres Irrigated	Acres Not Irrigated	Tons of Production Irrigated	Not Irrig.	Total	AUMs	No. of Bison	AUMs[1] at 50% Allowable Use	Months Sustained
230	100	311	165	476	1,587	100	793	7.9
230	100	311	165	476	1,587	150	793	5.3
230	100	311	165	476	1,587	200	793	4.0
230	100	311	165	476	1,587	250	793	3.2
230	100	311	165	476	1,587	350	793	2.3

[1] 50% may be an overly conservative estimate of allowable use on cured grass forage. Snow depths in the Hunter-Talbot area, however, may inhibit additional use of forage and/or cause bison to leave the area.

Carrying Capacity - With Haying

The following estimates were based on the same criteria as those above except it was assumed that one cutting of hay was taken off the irrigated haylands prior to the arrival of bison in the fall. The cut hay would be stored and available for bison during the winter, and it was included in the following estimates.

Tons of Production Irrigated	Not Irrig.	Total	Forage AUMs[1] Hay	Standing	Total	No. of Bison	No. of Months Sustained
311	165	476	1,037	275	1,312	100	13.1
311	165	476	1,037	275	1,312	150	8.7
311	165	476	1,037	275	1,312	200	6.6
311	165	476	1,037	275	1,312	250	5.2
311	165	476	1,037	275	1,312	350	3.8

[1] Based upon 100% use of the hay crop put up and 50% allowable use of standing forage on the non-irrigated fields.

Under this scenario, no allowance was made for regrowth of pasture grasses after the hay crop is harvested in early July. The regrowth could possibly contribute another 0.3 tons/per acre. With an allowable use factor of 50%, this would increase carrying capacity by another 115 AUM's, or another 0.8 months for 150 bison, or 0.6 months for 200 bison, or 0.5 months for 250 bison, or 0.3 months for 350 bison.

APPENDIX VI: CARRYING CAPACITY OF THE GREATER HUNTER-TALBOT AND MORMON ROW-KELLY HAYFIELDS AREAS

To estimate the potential 8-month carrying capacity of the available habitat for bison in the greater Hunter-Talbot area, forage production was sampled during August 1991-1995. Sampling was stratified by plant community type. Acreage of each type was calculated with a polar planimeter from 1:24,000 scale topographic maps and total production estimated using the U.S. Soil Conservation Service double sampling methodology. Vegetative biomass on 7 transects of 10 plots each was clipped, air-dried and weighed. The number of AUM's was based upon a 50% use factor of graminoid and alfalfa production and also on a 30% use factor. Mean annual forage utilization has averaged 31% on the NER from 1984-1990, indicating that a utilization rate of 50% may not be achievable in the Hunter-Talbot area. From these data, potential carrying capacities were estimated. The area that the estimates apply to is shown in Figure 2.

Plant Community	Year	Acres	Tons of Production		No. Months	AUMs (# Bison) at 50% Use	AUMs (# Bison) at 30% Use
			Per Acre	Total			
Formerly Irrigated Brome/Alfalfa	1991	230	1.35	311	8	518 (65)	311 (39)
	1992	230	1.04	240	8	400 (50)	240 (30)
	1993	230	1.48	340	8	567 (71)	340 (43)
	1995	230	1.24	285	8	475 (59)	285 (36)
	Average	**230**	**1.28**	**294**	**8**	**490 (61)**	**294 (37)**
Dryland Brome/Mixed Grass	1991	328	1.65	542	8	903 (113)	542 (68)
	1992	328	0.79	259	8	432 (54)	259 (32)
	1993	328	1.09	359	8	598 (75)	359 (37)
	1995	328	1.41	463	8	772 (96)	463 (58)
	Average	**328**	**1.24**	**406**	**8**	**676 (85)**	**406 (51)**
Big Sagebrush/ Grasslands	1991	860	0.20	172	8	287 (36)	172 (21)
	1992	860	0.23	197	8	328 (41)	197 (25)
	1993	860	0.31	265	8	442 (55)	265 (33)
	1995	860	0.40	347	8	578 (72)	347 (43)
	Average	**860**	**0.29**	**245**	**8**	**408 (51)**	**245 (31)**
TOTAL	1991	1,418	0.65	1,025	8	1,708 (214)	1,025 (128)
	1992	1,418	0.49	696	8	1,160 (145)	696 (87)
	1993	1,418	0.68	964	8	1,607 (201)	964 (121)
	1995	1,418	0.74	1,094	8	1,823 (228)	1,094 (137)
	Average	**1,418**	**0.67**	**945**	**8**	**1,575 (197)**	**945 (118)**

The following estimates of forage production on 3,776 acres in the Mormon Row-Kelly Hayfields area are also based on forage sampling conducted in August 1991-1994. Because it is difficult to speculate how much of this area could or would be utilized, a conservative estimate of 10% allowable use was used in preparing the following carrying capacity estimates.

Plant Community	Year	Acres	Tons of Production		No. Months	AUMs (# Bison) at 10% Use
			Per Acre	Total		
Brome/Mixed Grass	1991	1,981	0.67	1,327	8	442 (55)
	1992	1,981	0.89	1,757	8	586 (73)
	1993	1,981	0.85	1,676	8	559 (70)
	1995	1,981	1.06	2,034	8	678 (85)
	Average	**1,981**	**0.86**	**1,699**	**8**	**566 (71)**
Big Sagebrush/ Grasslands	1991	1,795	0.29	521	8	174 (22)
	1992	1,795	0.18	329	8	110 (14)
	1993	1,795	0.21	380	8	127 (16)
	1995	1,795	0.39	696	8	232 (29)
	Average	**1,795**	**0.27**	**482**	**8**	**161 (20)**
TOTAL	1991	3,776	0.49	1,848	8	616 (77)
	1992	3,776	0.55	2,086	8	695 (87)
	1993	3,776	0.54	2,056	8	685 (86)
	1995	3,776	0.72	2,730	8	910 (114)
	Average	**3,776**	**0.58**	**2,180**	**8**	**727 (91)**

APPENDIX VII: BRUCELLOSIS: AN OVERVIEW

The Bacterium

Of the several species of Brucella bacteria, only Brucella abortus is relevant to management of the JBH. Several different biovarieties (biovars) or biotypes of B. abortus exist. At least 8 biovars are recognized although 22 have been reported (Meyer 1990). All isolates from bison, except one, are biovar 1, the predominant biovar found in cattle. A small portion of cattle isolates are biovars 2 and 4 (Timoney et al 1988). A single isolate of biovar 2 has been made from a Yellowstone Park bison (Roffe et al. 1996). Elk in the greater Yellowstone ecosystem, including those sharing the NER with JBH, have had predominantly biovar 1 Brucella. A few instances of isolation of biovar 4 have occurred in elk (Thorne et al. 1991). By all measures, Brucella biovars are identical, regardless of the host species from which they are isolated. The disease was probably introduced to North America through infected European cattle.

B. abortus has a predilection for the pregnant uterus, mammary gland, testicle and accessory male sex glands, lymph nodes and lymphoid tissue such as spleen, and joints. The fetus produces a substance that stimulates the growth of the bacteria and probably is the reason for the large concentration of bacteria in fetal and placental tissues (Blood et al 1979). Cultures from aborting bison have yielded similar distributions (Rhyan et al. 1994, Roffe et al. 1996). Based on current understanding of the disease, primarily data from cattle, greatest organ damage occurs in the uterus and placenta, resulting in abortion. Abortion is most common in the last 3 months of pregnancy. Most animals will abort the first pregnancy following infection but a significant number of cattle (up to one-third) can abort on second and subsequent pregnancies (Nelson 1991). In addition calves may be stillborn or born infected and weak (Roffe et al. 1996). A small percentage of adult animals develop a chronic infection which may manifest itself as distended and inflamed joints. Disease in the male may lead to sterility. Usually this is temporary during acute infection, but permanent damage and sterility may result (Rankin 1965).

The pathogenesis and transmission of brucellosis in free-ranging bison is under debate. There may even be differences between bison from the JBH and those from the Yellowstone National Park herd. Preliminary data (Roffe et al. 1996) indicate that the distribution within the body and mode of infection in Yellowstone bison are similar to those in cattle. There are some documented differences between cattle and bison, however, such as reaction to vaccination (Davis 1993). Poor recovery of the Brucella organism from bison tissues (USDA-APHIS National Veterinary Services Laboratory 1992) is considered by some to indicate a fundamental difference between cattle and bison in terms of response to B. abortus, but others argue that the observed difference is due to incomplete sampling.

Some believe that the primary mechanism for intraspecific transmission in Yellowstone bison is milk (Meyer and Meagher 1995). If milk were the primary mode of transmission in bison, the risk to cattle would be minimal. Currently the preponderance of the evidence, however, suggests that birth/abortion products are the primary mode of brucellosis transmission (Williams et al. 1994). Thus we have based the predicted impacts of bison management on this presumption. Research is currently underway in Yellowstone National Park to further elucidate this question. The abortion rate in bison is unknown, but 4 abortions have been documented in Yellowstone National Park (Rhyan et al. 1994, Roffe et al. 1995, Roffe et al. 1996). Beale (1995) states that statistical evaluations of the data suggest abortion levels in bison could be similar to or greater than levels in cattle.

Brucellosis Diagnosis

The two primary means of diagnosing brucellosis are serology and bacteriology. Serology is based on detecting antibodies in the affected animal to Brucella antigens and thus is only an index of infection. Bacteriological isolation of Brucella provides a definitive diagnosis but is considerably more time consuming and can provide false negatives. Both systems have advantages and limitations.

Serologic diagnosis depends on the amount, class and biological activity of antibodies present, the relative proportions of the types of antibodies, the test procedure selected, the type of antigen used in the test, and cross-reactive agents in the test serum. Because of these variables each serologic test has its own level of specificity (the measure of a test's ability to truly reflect the presence of Brucella antibodies when positive) and sensitivity (the test's ability to detect low levels of antibody). False positives (positive test results in the absence of Brucella antibodies) and false negatives (lack of a positive test in the presence of Brucella antibodies) are common with certain tests. Less specific tests have more false positives. Less sensitive tests have more false negatives. Because no one brucellosis test has both high sensitivity and high specificity multiple tests are often used, particularly in wildlife, to increase the interpretive accuracy of blood test results.

Vaccination with strain 19 compounds the difficulties with serologic testing because antibodies to the vaccine, if present, will be detected by the test. Methods are currently being explored to differentiate vaccination antibodies from field infection antibodies. Another limitation of serology is that the test measures only antibody, not active infection. In most diseases antibodies persist long after the infecting agent has left the host. In brucellosis, specifically in cattle, there appears to be a high level of correlation between the presence of antibody and the presence of bacteria. At this time this appears to be true in elk but it is less certain in bison, particularly Yellowstone National Park bison, which have co-existed with the Brucella organism for over 75 years.

The most widely used serologic methods include the standard agglutination test (SAT), buffered plate agglutination test (BPAT), card test (a buffered agglutination test), Rivanol, and complement fixation (CF). The order of diagnostic sensitivity of these tests (highest to lowest) is Rivanol, card/BPAT, CF, and SAT. However, the order of specificity (highest to lowest) in cattle is CF, Card/BPAT, Rivanol, SAT (Wright and Nielsen 1990). The high diagnostic sensitivities of the Rivanol and card tests and their ease of conduct have made these assays very useful as screening tests. Confirmation of suspects is made with the highly specific CF test.

Numerous other systems have been utilized in the serologic testing for brucellosis. Only the enzyme linked immunosorbent assay (ELISA) has been widely accepted for use. Many different types, enzyme systems, antigens, and antibody reagents have been used in ELISA testing, but the most important are the indirect ELISA techniques which are used worldwide and the competitive ELISA which utilizes highly specific monoclonal antibodies. Both tests surpass the CF test in sensitivity but the indirect ELISA is slightly less specific than the CF. The competitive ELISA is much more specific than any other test and is currently in development for separating vaccination and field strain induced antibodies.

The standard by which other tests are evaluated for their ability to diagnose brucellosis is isolation of the bacteria. Although time consuming and expensive, isolation of Brucella confirms infection with the organism. While a positive culture is proof of infection, however, a negative culture does not prove non-infection. Sample selection and handling play a critical role in isolating the bacteria. Best sources of the organism include fetal lung and stomach content, placenta, lymphatic tissue and milk. In addition, because of its intracellular nature, the bacteria may be difficult to isolate and special techniques are used on tissue to liberate the organism. Although it is not possible to isolate the bacteria from every positive animal, most studies have shown that bacteriologic culture provides a good basis for evaluating serologic results (Pietz and Cowart 1980, Flagg 1983).

Brucellosis Vaccination

Brucellosis vaccination has been an integral part of the USDA brucellosis eradication program. Numerous vaccines, modified live and killed, have been tried, and with the exception of strain 19 vaccine, most met with poor success. Vaccination in cattle must meet several criteria: it must confer a reasonable amount of immunity, it must not cause disease, it must not be shed to infect other animals, and antibodies produced must not persist into adulthood. This last criterion is necessary to prevent interference with testing procedures used to monitor disease distribution and prevalence and to trace outbreaks. Currently the USDA Uniform Methods and Rules recommends vaccination in areas of high risk to livestock. If vaccination recommendations are utilized the UMR requires the use of "reduced dose" Brucella abortus strain 19 delivered to female bovine and bison calves no younger than 4 months or older than 12 months of age as a minimum standard. On rare occasions, strain 19 is used in adult female cattle. Strain 19 vaccination in cattle is about 65-75% effective in reducing abortions and somewhat less effective in averting field strain Brucella infection (Cheville et al. 1993).

The drawbacks of vaccination include vaccine shedding, persistent infections, and antibody persistence complicating diagnosis (Nicoletti 1990). A debate exists as to whether these criteria are important in wildlife. The primary focus of the brucellosis controversy concerning the JBH is the herd's potential to transmit disease to domestic cattle. At this time, seroprevalence is the primary means to measure the prevalence of brucellosis in the JBH and is therefore the primary index of hazard the herd poses to cattle. Because vaccination often interferes with this assay a strong case can be made that the vaccine should be shown to be highly effective in lowering the prevalence of disease in the herd and not be shed by or cause persistent infections in the host before it is used in bison or elk. Shedding also creates a concern regarding the potential effects of such a vaccine on non-target species such as moose. Suggestions have been made that shedding strain 19 could result in transmission to cattle, causing previously seronegative cows to become positive. Such seroconversion by oral ingestion of strain 19 does not appear likely (Nicoletti pers. comm. 1991). Transmission of strain 19 from a vaccinated bison to a domestic cow is a remote possibility, but should such transmission occur, it would not result in loss of a state's cattle brucellosis-free status because the strain 19 organism is easy to distinguish (through isolation) from field strain Brucella.

Vaccination is currently practiced on some feedground elk managed by Wyoming Game and Fish (Thorne et al. 1981). Vaccine encased in a methylcellulose pellet is delivered by remote ballistic injection. Work has begun to determine the effectiveness of the program in reducing herd infection rate. Studies on captive elk have been summarized by Herriges, et al. (1989). Some positive effect of vaccination was detected (calving success rate following challenge was 33% in non-vaccinates and 62% in vaccinates; infection rates following challenge were 69% in non-vaccinates and 45% in vaccinates), but statistically significant conclusions could not be drawn because of small sample sizes and specific methods used.

Captive bison are currently regulated under the brucellosis eradication program of many states. Vaccination procedures and age of vaccination are based on the assumption of similarity with cattle.

Controlled studies (Davis 1993) of strain 19 calfhood vaccination in bison showed that no protection was afforded to vaccinated calves (5% increase in abortion and 8% decrease in infection in vaccinated calves). Controlled studies of strain 19 vaccination in adult pregnant bison (Davis et al. 1991) demonstrated an efficacy of 63% against abortion and 39% against infection. However, 58% of vaccinated bison aborted and shed strain 19.

Use of adulthood vaccination combined with test and removal has effectively controlled brucellosis in large cattle herds (Nicoletti 1979), yet persistent antibody titers were rare and strain 19 abortions were absent. Studies conducted by Nicoletti (pers. comm. 1991) indicated large amounts of strain 19 fed orally to cattle did not induce disease or cause persistent titers. This would suggest that transmission of strain 19 from bison to cattle may not be biologically important.

Brucellosis in Humans

Brucellosis, and consequently the disease in humans, has a worldwide distribution. Because of the nature of brucellosis transmission, the disease will transmit from infected animals to humans but is not contagious among people. Most species of Brucella are potentially infectious to people, although B. melitensis and B. suis are the most invasive and cause the most severe disease (Barton 1991). B. abortus is generally less severe. Most cases of human brucellosis are caused by B. melitensis. Human infection with Brucella is referred to as undulant fever or, in the case of B. melitensis, as Malta fever.

Human disease can be acute to very chronic and the disease has a tendency to recur. Clinical signs are usually referred to as "flu-like" and may include weakness, fever, chills, sweating, loss of appetite and generalized aches. Brucellosis may infect any organ and can be severely crippling or life threatening.

On a worldwide basis the primary mode of infection to the human population is through food. Epidemiological evidence indicates milk and milk products as the primary sources of brucellosis. Bacteria are reported to survive 2-4 months in chilled milk products (Barton 1991). Occupational contact with infected animals (such as meat inspectors and abattoir workers) is the second most important means of transmission to humans. Infection occurs from infected animal tissues through small wounds in the skin or inhalation of bacteria-containing aerosols.

In general the risk to humans from wild populations with B. abortus is dependent upon their contact with infected tissues. Risk of transmission would be highest from handling aborted or reproductive tissues. There has been no documentation of transmission to hunters in Wyoming. One human case of brucellosis from an infected elk fetus has been documented in Montana (Davis 1991). Given the dearth of reports of human cases of brucellosis, especially considering early bison reduction activities and current hunting activities for elk, the risk of transmission to humans is considered small. The Centers for Disease Control no longer lists brucellosis as a reportable disease.

Strain 19 (the vaccine strain of B. abortus) is a potential human pathogen, although its effects are less severe than field strains of Brucella abortus. Surveys of veterinarians using strain 19 indicated it was low risk (Young 1991), but reports indicate that strain 19 inoculated either accidentally or experimentally can cause disease of similar severity to that caused by field strains of Brucella (Nicoletti 1989).

APPENDIX VIII: BRUCELLOSIS TEST RESULTS FOR JACKSON BISON HERD

YEAR	ANIMAL #	SEX	BRUCELLOSIS SEROLOGY[1]	BRUCELLA CULTURE
1990	1	MALE	REACTOR	
1990	2	MALE	REACTOR	
1990	3	FEMALE	NEGATIVE	
1990	4	FEMALE	REACTOR	
1990	5	MALE	NOT TESTED	
1990	6	MALE	NEGATIVE	
1990	7	FEMALE	INC. TEST[2]	
1990	8	FEMALE	REACTOR	
1990	9	FEMALE	REACTOR	
1990	10	MALE	SUSPECT	
1990	11	FEMALE	REACTOR	
1990	12	FEMALE	REACTOR	
1990	13	MALE	INC. TEST[2]	
1990	14	FEMALE	SUSPECT	
1990	15	MALE	REACTOR	
1990	16	MALE	REACTOR	
1990	17	FEMALE	REACTOR	
1990	18	MALE	REACTOR	
1990	19	MALE	REACTOR	
1990	1-CORA[3]	MALE	REACTOR	
1990	2-CORA[3]	MALE	REACTOR	
1990	3-CORA[3]	MALE	NEGATIVE	
1989	1	MALE	REACTOR	NEGATIVE
1989	2	FEMALE	NEGATIVE	
1989	3	MALE	REACTOR	NEGATIVE

YEAR	ANIMAL #	SEX	BRUCELLOSIS SEROLOGY	BRUCELLA CULTURE
1989	4	FEMALE	NEGATIVE	
1989	5	MALE	REACTOR	NEGATIVE
1989	6	FEMALE	NEGATIVE	
1989	7	MALE	NEGATIVE	
1989	8	FEMALE	REACTOR	NEGATIVE
1989	9	MALE	REACTOR	NEGATIVE
1989	10	FEMALE	NEGATIVE	
1989	11	MALE	REACTOR	NEGATIVE
1989	12	FEMALE	REACTOR	POSITIVE
1989	13	MALE	REACTOR	NEGATIVE
1989	14	FEMALE	REACTOR	POSITIVE
1989	15	MALE	REACTOR	POSITIVE
1989	16	FEMALE	REACTOR	POSITIVE

[1] Based on 4 tests (Plate, Card, Rivanol, C.F.).
[2] Incomplete test: fewer than 4 tests run on serum.
[3] Animals destroyed by WGFD near Cora, Wyoming (assumed from Jackson Herd).

SUMMARY:

Serology

Males: 16/19 (84%) seropositive or suspect
Females: 11/16 (69%) seropositive or suspect
Total: 27/35 (77%) seropositive or suspect

Culture

Males: 1/7 (14%) reactors culture positive
Females: 3/4 (75%) reactors culture positive
Total: 4/11 (36%) reactors culture positive

APPENDIX IX: ECONOMIC IMPACTS ASSOCIATED WITH NON-CONSUMPTIVE AND CONSUMPTIVE USES OF BISON

ECONOMIC VALUE OF OBSERVING BISON

Although difficult to quantify, there is a significant economic value associated with the observation of wildlife such as bison. This value represents the net benefit to the individual from the viewing of wildlife. In 1990, the U.S. Forest Service estimated the value of viewing wildlife at between $64.90 and $84.31 per group per trip for trips where the primary activity was wildlife observation (McCollum et al. 1990). In 1992, the Wyoming Game and Fish Department valued the non-consumptive use of wildlife at $52.29 per person per day (W. Gasson, WGFD, Cheyenne, WY pers. comm.). Species-specific values were not available from either of those sources. Preliminary work in Yellowstone National Park, in conjunction with wolf recovery, found that a trip to Yellowstone without seeing elk was worth $21.66 less per person to regional residents and $145.34 less per person to out-of-region residents than a trip to Yellowstone with seeing elk (Duffield 1991). The study also estimated that a 20 percent reduction in the park's elk population might reduce the probability of seeing an elk from 77 to 74 percent. This reduction would reduce the value of a trip by an estimated $0.63 for residents and $4.61 for nonresidents. Unfortunately, none of these sources had values specifically for bison viewing. Given the imposing nature of bison, however, it is likely that bison viewing is at the upper end of the range of values discussed above.

In addition to the difficulty in establishing a per unit value of bison viewing, there is also the problem of measuring the quantity of viewing. No information is currently available on the number of people or the length of time spent viewing the Jackson bison herd. Furthermore, no information is available on how the quantity of bison viewing would change under the various alternatives. As a result it was not possible to quantify the economic value of observing the Jackson bison herd, beyond a recognition that a significant economic value does exist.

ECONOMIC IMPACT OF A BISON SPORT HUNT ON TETON COUNTY

Under the bison sports hunt alternative the desired herd size would be maintained by allowing both non-residents and residents to apply for a license to hunt bison through the Wyoming Game and Fish Department. Successful applicants would be accompanied by personnel from the Wyoming Game and Fish Department who would select specific animals to be culled annually. Desired age and sex ratios for the herd would be maintained because hunters would not be allowed to select their own animal. Considerable interest has been shown in a bison sports hunt with over three thousand applications being received during the first drawing for sixteen permits in 1990.

This alternative would have an economic impact on the local economy through expenditures made by bison hunters during their stay in the area. In addition, license fee revenue would be generated for the Wyoming Game and Fish Department to partially offset the cost of administering the hunt. As no expenditure information was found specifically for bison hunters, Wyoming Game and Fish Department expenditure data for non-resident elk hunters was used as a proxy for bison hunters. Since the proposed bison hunt would occur in December, reducing the opportunity for camping by hunters, it was deemed more appropriate to use the non-resident hunter expenditure estimates rather than the lower resident expenditure figures.

The following is a list of the assumptions used to estimate bison hunter expenditures:

1. Average daily expenditures would be $ 225.18 per hunter (based on data for non-resident elk hunters from Annual Report 1994, Wyoming Game and Fish Department).

2. Average length of stay in the area would be 3 days per hunter, with 2 days spent hunting and 1 additional day spent in the area (personal communications with agency personnel).

3. Resident licenses would cost $275 and non-resident licenses would cost $1,688 (Wyoming Game and Fish Department 1996).

4. Eighty percent of the available bison licenses would go to residents with 20 percent going to non-resident hunters (personal communication with agency personnel).

5. All hunters would reside outside Teton County and the success ratio for hunters would be 100 percent.

Based on the above assumptions, it is estimated that total expenditures per bison hunter would equal $1233.14 with $675.54 being spent in the local economy during the hunt and an average of $557.60 going to the Wyoming Game and Fish Department for license fees:

$225.18 Per Day * 3.0 Days Per Hunter	$675.54
($275 Resident *.80) + ($1,688 Nonresident *.20)	$557.60
Total Expenditures Per Bison Hunter	$1233.14

Measurement of economic impact considers not only the direct effects of an economic activity such as bison hunting, but also the secondary effects resulting from the re-spending of bison hunters' dollars in the local economy. This is sometimes referred to as the "multiplier effect." Table 2 shows that the $675.54 in local spending by each bison hunter would generate a total of $935.56 in direct and secondary economic activity in Teton County. About 17 percent of this economic activity ($159.05) would be in the form of personal income for the area's population. These estimates are based on a preliminary version of an input/output model being developed for Teton County by the Wyoming Cooperative Extension Service. The analysis does not consider any potential local impacts resulting from local spending of the license revenue or the expenditures associated with administering the hunt.

Table 1 summarizes local expenditures, total economic activity, and personal income from a bison sports hunt with 5, 10, 25, and 33 hunters, respectively. License revenue from each level of hunting is also shown.

Table 1. Summary of Economic Impact and License Fee Revenues

Number of Hunters	Total County Spending	Total Economic Activity	County Personal Income	License Fee Revenue
5	$3,378	$4,678	$810	$2,788
10	$6,755	$9,356	$1,621	$5,576
25	$16,889	$23,389	$4,051	$13,940
33	$22,293	$30,873	$5,348	$18,401

Bison are often a significant tourist attraction in the Moran area of the Park, during July and August. Because of the bison's popularity with tourists, traffic or "buffalo jams" are common during this time of year. During the rest of the year the bison favor ranges that make them much less visible and accessible to large numbers of tourists compared to bison in Yellowstone.

Due to the non-consumptive recreation opportunities associated with bison, there may be some trade-offs between hunting bison and other recreational activities such as viewing and photographing bison. However, the gregarious nature and herding instincts of bison, as noted in the draft management plan, suggest that such trade-offs would be relatively minor. The opportunity to view bison is probably not as tied to a single animal as it is to a herd of animals. Thus the small changes in the number of animals in the herd resulting from hunting should not seriously affect non-consumptive recreation opportunities.

Table 2. Economic Impact Per Bison Hunter on Teton County

Sectors	Direct Effect	Secondary Effect	Total Effect	Employment
1 Agriculture	0.00	1.66	1.66	0.000000
2 Ag Services	0.00	0.45	0.45	0.000000
3 Timber	0.00	0.17	0.17	0.000000
4 Oil & Gas	0.00	0.60	0.60	0.000000
5 Mining	0.00	0.22	0.22	0.000000
6 Construction	0.00	4.61	4.61	0.000000
7 Manufacturing	37.83	5.79	43.62	0.000201
8 Transport\Comm	0.00	9.08	9.08	0.000000
9 Utilities	0.00	4.79	4.79	0.000000
10 Trade	100.65	24.88	125.53	0.004600
11 Eat/Drk/Lodg	166.86	5.30	172.16	0.007395
12 F.I.R.E.	0.00	24.07	24.07	0.000000
13 Services	14.86	12.66	27.52	0.000549
14 Health	0.00	3.75	3.75	0.000000
15 Local Gvt	0.00	10.05	10.05	0.000000
16 Households	10.13	151.93	162.06	0.000000
17 Other F.P.	111.46	0.00	111.46	0.000000
18 Imports	233.75	0.00	233.75	0.000000
Totals	675.54	260.02	935.56	0.012744