National Park Service
U.S. Department of the Interior

Yellowstone National Park
Idaho, Montana, Wyoming

Brucellosis Remote Vaccination Program for Bison in Yellowstone National Park

DRAFT Environmental Impact Statement

March 24, 2010

ON THE COVER
Bison in Yellowstone National Park. NPS photo.

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Draft Environmental Impact Statement Brucellosis Remote Vaccination Program for Bison in Yellowstone National Park

Type of Action:	Administrative
Lead Agency:	U.S. Department of the Interior, National Park Service
Responsible Official:	Suzanne Lewis, Superintendent, Yellowstone National Park

Abstract

This Environmental Impact Statement includes assessments of available information regarding the remote delivery vaccination of bison and a determination of whether currently available methods provide a mechanism for decreasing the disease prevalence of brucellosis in the Yellowstone bison population. Remote delivery is distinguished from hand (syringe) delivery that currently occurs in capture pens near the park boundary because it would not involve capture and handling of bison. The purpose for taking action is directed by a 2000 Record of Decision for the Interagency Bison Management Plan regarding the release of bison outside the park that are untested for exposure to brucellosis, which is caused by the non-native bacteria *Brucella abortus*. The need for remote delivery vaccination is to protect Yellowstone bison by reducing brucellosis infection and, as a result, further reduce the risk of transmission to cattle outside the park.

The goal of a remote delivery vaccination program would be to deliver a low risk, effective vaccine to eligible bison inside the park to (1) decrease the probability of individual bison shedding *Brucella abortus*, (2) lower the brucellosis infection rate of Yellowstone bison, and (3) test, monitor, and adjust for a safe, effective, low-risk, in-park remote delivery system for vaccination-eligible bison within the park. Three alternatives are evaluated in the Draft Environmental Impact Statement. The no action alternative describes the current hand vaccination program that is intermittently implemented at the Stephens Creek capture facility during capture operations. The second alternative includes a combination of the capture program at Stephens Creek and a remote delivery vaccination strategy that would focus exclusively on young, non-pregnant bison. The most logical strategy for remote delivery of vaccine at this time is using a compressed air-powered rifle that delivers an absorbable bullet with a vaccine payload that is freeze dried or photo-polymerized. Remote delivery vaccination could occur from mid-September through November and March through May in areas where bison are distributed in the park. A third alternative includes all components of the second alternative, as well as the remote vaccination of adult females.

Public Comment

You may submit written comments through the NPS Planning, Environment and Public Comment (PEPC) Internet website (http://parkplanning.nps.gov/yell) or mail them to the superintendent at the address below. Before including your address, phone number, e-mail address, or other personal identifying information in your comment, you should be aware that your entire comment (including your personal identifying information) may be made publicly available at any time. While you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so. Comments are due by midnight (MDST) 60 days after the date the Environmental Protection Agency publishes the Notice of Availability. The precise date the public comment period will close will be posted on the PEPC website listed above.

Superintendent, Yellowstone National Park
Brucellosis Remote Vaccination Program for Bison DEIS Comments
P.O. Box 168, Yellowstone National Park, Wyoming 82190

Draft Environmental Impact Statement Brucellosis Remote Vaccination Program for Bison in Yellowstone National Park

Executive Summary

Brucellosis is a contagious disease caused by *Brucella abortus* (a non-native bacteria) that may induce abortions or the birth of non-viable calves in livestock and wildlife. When livestock are infected, herds are often slaughtered and trade restrictions may be imposed. Brucellosis has been eradicated in cattle herds across most of the United States, with the exception of the Greater Yellowstone Area where bison and elk persist as one of the last reservoirs of infection. Approximately 40–60% of Yellowstone bison have been exposed to *B. abortus*.

After intensively managing bison numbers for 60 years through husbandry and culling, Yellowstone National Park instituted a moratorium on removing ungulates within the park in 1969 and allowed numbers to fluctuate in response to weather, predators, and resource limitations. Abundance increased rapidly and bison began large-scale migrations by bison out of the park during winter in the late 1980s. Attempts to deter these movements or bait animals back into the park failed and about 3,100 bison were removed from the population during 1984-2000. These migrations and removals led to a series of conflicts among various publics and management entities regarding issues of bison conservation and disease containment. As a result, the federal government and State of Montana agreed to an Interagency Bison Management Plan that established guidelines for managing the risk of brucellosis transmission from bison to cattle by implementing hazing, test-and-slaughter, hunting (outside the National Park), vaccination, and other actions near the park boundary.

The National Park Service agreed in the 2000 Record of Decision for the Interagency Bison Management Plan to evaluate an in-park, remote delivery vaccination program for bison. The goal of the in-park vaccination program is to deliver a low risk, effective vaccine to eligible bison inside Yellowstone National Park to (1) decrease the probability of individual bison shedding field strain *B. abortus*, (2) lower the brucellosis infection rate of Yellowstone bison, and (3) test, monitor, and adjust for a safe, effective, low risk, in-park remote delivery system for vaccination-eligible bison within the park.

This document includes assessments of available information regarding the remote delivery vaccination of bison and a determination of whether currently available methods provide a mechanism for decreasing the disease prevalence of brucellosis in the Yellowstone bison population. The purpose for taking action is to address National Park Service responsibilities directed by a 2000 Record of Decision for the Interagency Bison Management Plan Final Environmental Impact Statement. Remote delivery vaccination is needed to protect Yellowstone bison by reducing brucellosis infection and, as a result, further reduce the risk of transmission to cattle outside the park. To ensure bison remain as wild and free-ranging as possible within the constraints imposed by all of the mandates of the agencies charged with

managing them, the Joint Management Plan in the 2000 Record of Decision anticipates gradually increasing tolerance of bison not tested for brucellosis onto winter range outside the north and west boundaries of the park. However, the release of untested bison outside the park relies on the initiation of a remote vaccination program for bison within the park with a low risk and effective vaccine and remote delivery system. The Record of Decision indicated that additional National Environmental Policy Act analysis would occur prior to initiating a park-wide, remote vaccination program.

The collective actions of the Interagency Bison Management Plan are intended to preserve a population of native bison as a component of a naturally functioning ecosystem, while allowing some bison to occupy low-elevation winter ranges on public lands outside Yellowstone National Park. The vaccination program is specifically intended to protect Yellowstone bison from brucellosis by reducing the probability that individual bison become infected and subsequently become transmission vectors to other bison. Indirectly, this program will reduce the probability of brucellosis transmission from Yellowstone bison to livestock that share ranges on habitats outside the park.

Several areas of controversy have been identified during the course of this study. While all proposed actions are within the broad discretion of National Park Service policies for preservation of native wildlife, many constituencies reject the idea of active management to reduce the prevalence of brucellosis in the Yellowstone bison population. The effectiveness of Strain RB51 vaccine against field strain *B. abortus* is not conclusive and mixed results have been reported by various research projects. The USDA–Agricultural Research Service has published results of research showing that only 15% of vaccinated bison aborted pregnancies when experimentally challenged by a virulent strain of *B. abortus*, while 62% of non-vaccinates aborted their pregnancies. Conversely, experiments conducted by Texas A&M University concluded that vaccination with Strain RB51 provides no protection from aborted pregnancies. The results are not comparable because methods were not consistent. However, the Scientific Advisory Subcommittee on Brucellosis United States Animal Health Association, which includes the authors of these two disparate studies, has reviewed these studies and concluded in 2008 that experimental data for hand vaccination of bison with Strain RB51 suggests a 50-60% reduction in abortions, 45-55% reduction in infection of uterine or mammary tissues, and a 10-15% reduction in infection. Furthermore, the Subcommittee concluded that currently available data suggests remote delivery induces protection that is less than hand vaccination.

In addition, much debate has occurred over the appropriateness of vaccinating free-ranging wildlife in a national park. Livestock regulatory and disease control agencies have supported this concept in multiple venues. While vaccination is legal and likely both feasible and useful in wildlife disease management, some interest groups reject the idea. The main reasons cited for not wanting to vaccinate include the disturbance of wildlife, the belief that vaccination is an inappropriate management tool in a national park, and that vaccination is contrary to their personal values.

This analysis will determine whether to proceed with implementation of remote delivery vaccination of bison throughout Yellowstone National Park. Remote delivery vaccination is part of a phased-in, adaptive management strategy described in the Final Environmental Impact Statement and 2000 Record of Decision for the Interagency Bison Management Plan. Through adaptive management, the Interagency Bison Management Plan is designed to progress through a series of management steps that initially tolerate only bison testing negative for brucellosis on winter ranges outside Yellowstone, but will eventually tolerate limited numbers of untested bison on public land outside Yellowstone during winter when cattle are not present. The partner agencies involved with the Interagency Bison Management Plan include the U.S. Department of Agriculture's (USDA) Animal and Plant Health Inspection Service and Forest Service; the Department of the Interior's (USDI) National Park Service; and the State of Montana's Department of Fish, Wildlife, and Parks and Department of Livestock. These agencies met several times in public venues during 2008 and 2009 to assess the effectiveness and outcomes of management activities during 2000-2009, and develop and incorporate short and long-term adaptive management actions based on prevailing conditions. An adaptive management agreement was signed by the partner agencies in December 2008 to guide the operating procedures during winter 2008-09 and beyond. The partner agencies will continue to adjust strategies to manage bison abundance and distribution on lands adjacent to Yellowstone National Park based on evaluations of new conservation easements, land and wildlife management goals, reduced brucellosis prevalence in bison, and new information or technology that reduces the risk of disease transmission between wildlife and livestock.

The alternative actions described in this analysis build upon the adaptive management paradigm for resolving conflicts through implementation of actions and subsequent monitoring to learn how the bison population responds. Three alternatives are evaluated in the Draft Environmental Impact Statement. The no action alternative (A) describes the current hand vaccination program (i.e., syringe delivery of SRB51 *B. abortus* vaccine) that is sporadically implemented at the Stephens Creek capture facility when hazing of bison becomes ineffective at maintaining spatial separation from private properties north of the park boundary. This alternative relies on capturing bison that move to the Reese Creek boundary area, containing them within the fenced paddocks of the facility, individually handling each animal, conducting blood tests to determine past exposure to brucellosis, and vaccinating young (calf and yearling) animals by syringe injection. Since the implementation of the IBMP in 2000, the NPS has only implemented hand vaccination at the Stephens Creek capture facility in 2004 (112 yearling and calf bison) and 2008 (24 yearling and calf females).

The second alternative (B) includes a combination of the existing program at Stephens Creek and a remote delivery vaccination strategy that would focus exclusively on young, non-pregnant bison (both sexes). This alternative expands the vaccination program to the whole park but continues targeting the existing focal group. Remote delivery vaccination could occur from mid-September through November, and March through May, in many areas where bison are distributed in the park. Remote delivery vaccination would not involve capture and handling of individual animals. The most feasible technology currently available for remote delivery of vaccine to animals without individually handling them is through the use of a compressed air powered rifle that delivers an absorbable projectile with freeze dried or photo-polymerized vaccine encapsulated in the payload compartment (Biobullet®, SolidTech Animal Health, Newcastle, Oklahoma). Bison congregate en masse in two areas during the July to August breeding season and disperse over 220,000 acres of habitat during the remainder of the year. As bison disperse, the average group size decreases, making it easier to work in close proximity to bison from mid-autumn through spring.

The third alternative (C) is similar to the second alternative, but also includes the vaccination of adult females. Vaccination of adult females provides two benefits not available under Alternative B. This action anticipates addressing problems associated with the short duration of immunity provided by the currently available vaccine (Strain RB51) and increasing population-level immunity by more quickly providing vaccine to a larger pool of candidates eligible for vaccination. Some evidence from experiments on captive bison has shown that vaccinating pregnant bison late in the pregnancy period can create an abortion response due to the vaccine. However, delivery of vaccine during the earlier stages of the pregnancy has been shown to be low risk, especially for those bison that were previously vaccinated as young animals.

The vaccination program is intended to lower the amount of *B. abortus* bacteria shed into the environment by the Yellowstone bison population. This in turn should decrease the percentage of bison in the population that are exposed to the pathogen and potentially infected with brucellosis. Model simulations indicate all three alternatives should result in a decrease in brucellosis prevalence in the Yellowstone bison population. Alternative C should provide the greatest beneficial effect in lowering disease prevalence because it reduces the probability of infected bison aborting pregnancies to a greater extent and in a shorter period of time than the other alternatives. As a result, Alternative C will more effectively reduce the amount of *B. abortus* bacteria shed in the environment for naïve (i.e., previously uninfected) individuals to encounter. In addition, Alternative C will best address the problem of potential decreased immunity later in a vaccinated animal's life by ensuring repeat vaccination of all adult females. This action may affect, but is not likely to adversely affect, the federally threatened Canada lynx, gray wolf, and grizzly bear. Impacts to other wildlife species (e.g., disturbance; possible exposure to vaccine) would be adverse and localized in the short-term, but minor, localized, and beneficial in the long-term. Impacts to ethnographic resources (e.g., cultural and spiritual significance of bison) would be adverse in the short-term, but may be minor and beneficial in the long-term. Impacts to human health and safety, visitor experience, and park operations (e.g., disturbance; possible exposure to vaccine) would be adverse but short-term, localized, and minor in magnitude. The proposed remote delivery vaccination actions will be implemented with federal funding and will not reduce the seroprevalence of brucellosis sufficiently (i.e., eradication) to alter perceptions of livestock operators, producers, and regulators regarding the risk of brucellosis transmission from bison and elk to cattle. Thus, effects to socioeconomics, including employment, occupation, income changes, tax base, and infrastructure, will be negligible.

An adaptive management process will be used to evaluate and, if necessary, modify actions during implementation to facilitate effective outcomes. The duration of immunity provided by remote vaccination remains uncertain, primarily because of unknown physiological effects and the logistical details of manufacture and delivery of vaccine. Detailed, short-term studies and a longer term surveillance strategy were developed to gather information for assessing this issue.

Contents

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Figures

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Tables

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Acronyms

CFR	Code of Federal Regulations
DO-12	Director's Order 12
EIS	Environmental Impact Statement
FEIS	Final Environmental Impact Statement
FR	Federal Register
GYE	Greater Yellowstone Ecosystem
IBMP	Interagency Bison Management Plan
NEPA	National Environmental Policy Act
NPS	National Park Service
ROD	Record of Decision
SRB51	Strain RB51 vaccine
USDA	U.S. Department of Agriculture
USDI	U.S. Department of Interior
USFWS	U.S. Fish and Wildlife Service

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1. Chapter 1: Purpose of and Need for Action

1.1 Introduction

The National Park Service (NPS) is considering implementing a remote delivery vaccination program for free-ranging bison (*Bison bison*) in Yellowstone National Park, an action previously directed by the Record of Decision (ROD) for the Final Environmental Impact Statement (FEIS) regarding the Interagency Bison Management Plan (IBMP; U.S. Department of Interior [USDI] and U.S. Department of Agriculture [USDA] 2000*a*, *b*).

The Yellowstone bison population is comprised of plains bison that historically occupied about 20,000 km^2 in the headwaters of the Yellowstone and Madison rivers of the western United States (Schullery and Whittlesey 2006). They were nearly extirpated in the early 20th century, with Yellowstone National Park providing sanctuary to the only wild and free-ranging population (Plumb and Sucec 2006). Intensive husbandry, protection, and relocation were used to restore the population (Meagher 1973) and, today, more than 3,000 bison are an integral part of the ecosystem. Yellowstone bison are the last continuously free-ranging wild bison in the United States (Appendix A). These bison are an integral part of the ecological processes and aesthetic purposes of the park that provide prey for predators and carrion for scavengers, contribute to the recycling of nutrients, and provide the visiting public with a vignette of how this icon of the American frontier existed in the early settlement era (Freese et al. 2007, Sanderson et al. 2008).

Bison began to seasonally migrate and expand their winter range (i.e., dispersal) onto lower elevation areas along the boundary of Yellowstone National Park and into Montana as numbers increased during the 1980s (Meagher 1989, Taper et al. 2000, Bruggeman et al. 2009c) and bison experienced moderate nutritional deficits (Coughenour 2005). These movement processes occurred well before under-nutrition became sufficient to decrease survival and recruitment or cause significant deterioration to vegetation and soils (Coughenour 2005), suggesting that bison regulated their local densities in the park by moving to lower elevation locations in and outside the park (Coughenour 2008, Plumb et al. 2009). Similar to bighorn sheep, elk, and pronghorn that summer in the park, migration during winter allows bison to access food resources that are more readily available in lower snow depth areas of their range, and serves to release portions of the bison range in the park from intensive use for a portion of the year. Thus, migration by bison onto lower elevation winter ranges along the boundary of the park and into adjacent areas of Montana is essential for bison to access greater food supplies through the year and efficiently use available resources.

If migration by bison into Montana is restricted (e.g., bison forced to remain within the park by humans), then bison numbers would ultimately be regulated by food availability in the park, with bison reaching high densities (Coughenour 2008) before substantial winterkill (i.e., starvation) occurs. These high densities could cause significant deterioration to other park resources (e.g., vegetation, soils, other ungulates) and processes as the bison population approaches or overshoots their food capacity in the park. Alternatively, under the 2000 ROD for the IBMP, brucellosis risk management actions could be implemented to periodically to reduce the numbers of bison attempting to move outside the park, resulting in sporadic large-scale (more than 1,000 bison) shipments to slaughter. Either way, without the process of migration operating across the boundary of Yellowstone National Park, bison would not have access to historic and essential winter ranges outside the park, which could adversely affect their long-term conservation (Plumb et al. 2009). Also, the ecological role of the largest remaining free-ranging plains bison population in the world would be diminished (Freese et al. 2007, Sanderson et al. 2008) which, in turn, would diminish the ecological processes within the park (Coughenour 2008) and diminish the suitability of the park to serve as an ecological baseline (i.e., benchmark) for assessing the effects of human activities outside the park (Boyce 1998, Sinclair 1998).

The Yellowstone bison population has been known to be infected with brucellosis since it first tested positive in 1917 (Barmore 1968). Brucellosis is a contagious disease caused by the non-native bacteria, *Brucella abortus*, and infects wildlife, domestic animals, and humans (Cheville et al. 1998, more detailed information available in Appendix B). The state of Montana, especially those associated with the livestock industry, are concerned about Yellowstone bison as a potential re-infection vector to livestock near the bison conservation area. Acceptance of Yellowstone bison as wildlife on lands outside Yellowstone National Park falls under the jurisdiction of the state of Montana. The IBMP (a court negotiated settlement between the state and the federal agencies) required the NPS to develop an in-park vaccination program as the risk management basis for state managers to accept untested, free-ranging Yellowstone bison on lands outside the park.

The transmission of brucellosis from bison to cattle requires that infected, pregnant bison shed *B. abortus* outside the park during a *Brucella*-induced abortion or infectious live birth, and that a susceptible domestic cow encounters the shed bacteria by (1) licking infectious birth tissues, or (2) grazing on vegetation where *B. abortus* has been left behind as the amniotic fluid is dispersed during the birthing process (explained in detail below). Suitable winter range for bison extends onto public lands outside Yellowstone National Park, where cattle may encounter shed bacteria. Concern over the risk of brucellosis transmission to cattle drives the need to prevent commingling with bison.

1.1.1 Brucellosis Transmission and Infection

Brucellosis can be transmitted not only between individuals of the Yellowstone bison population, but also between bison and elk (*Cervus elaphus*), elk and cattle, and bison and cattle (Flagg 1983, Davis et al. 1990, Cheville et al. 1998). All three species can shed the bacteria and be the source of disease spread.

While transmission of brucellosis in wild ungulates is poorly understood, transmission within the bison population is known to occur primarily through contact with bacteria shed by infected adult females at the time of aborted pregnancies or successful live births (Figure 1). Brucellosis is transmitted when animals ingest the bacterium shed via an aborted fetus, afterbirth, or other reproductive tract discharges—especially just prior to, during, or soon after abortion or live birth (Williams et al. 1993, Rhyan et al. 1994). Milk may provide an important secondary mode of transmission when actively infected adult females nurse their young calves (Rhyan and Drew 2002).

Brucellosis can infect male and female bison regardless of age (Rhyan et al. 2009). However, females are more likely to shed an infective dose. The amount of bacteria shed by infected bison males is small and likely inconsequential relative to transmission risk (Lyon et al. 1995). The incubation period (i.e., time between exposure and onset of infection) for the *Brucella* bacteria varies widely depending on exposure dose, as well as on host age, sex, species, susceptibility, stage of gestation, and previous vaccination status (Nicoletti and Gilsdorf 1997). Onset of infection is generally brief and systemic, and typically followed by the *Brucella* bacteria localizing in the lymphatic system of either sex. For female bison the bacteria may also localize in the udder or, depending on the stage of gestation, reproductive tissues.

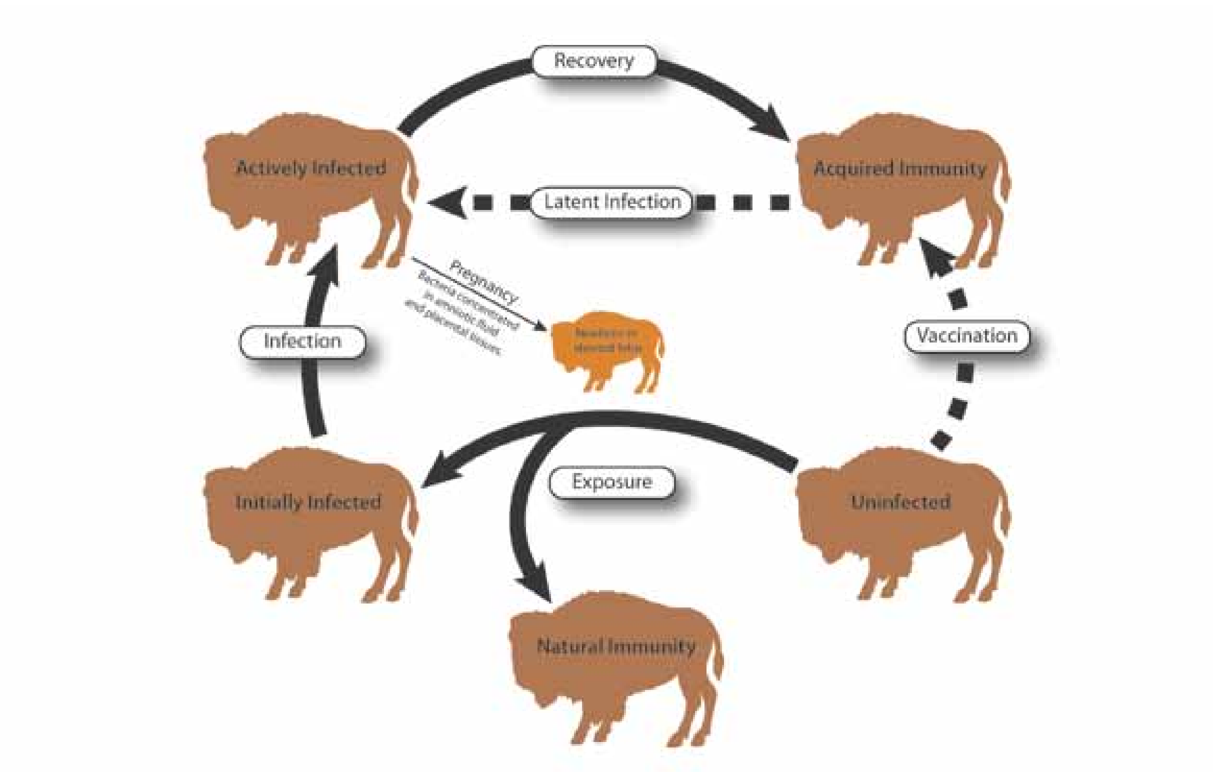

Figure 1. Brucellosis transmission cycle.

The processes associated with exposure, infection, and shedding of *B. abortus* in bison are complex. Once *Brucella* organisms are introduced to a susceptible bison by direct contact with a mucous membrane, specialized white blood cells from the bison's immune system ingest the bacteria. Bacteria are recognized as foreign materials, ingested by white blood cells, and then transported to tissues in the lymphoid system where lymphocytes (T and B cells) conduct different functions that contribute to an immune system response to infection. The humoral response is associated with B cell lymphocytes secreting antibodies that connect like a puzzle to the antigen of the invading bacteria. Once the antibodies bind with the invading microbe, the microbes become dysfunctional. The antibody also signals for macrophage cells to destroy the antibody-antigen complex and attached microbe. The cell-mediated response is associated with T cell lymphocytes that function in two ways. A portion of the T cells seek and destroy cells that are already infected by the invading microbe. Other T cells send chemical signals to activate a variety of specialized immune system cells that actively respond to the infection until the foreign materials are no longer recognized in the body.

Some *B. abortus* cells will survive immune system response and remain dormant in the lymph system tissues until such time as host conditions again allow abundant replication of the bacteria. Transmission of the disease can be accomplished by two routes:

- *horizontally* via association and exposure of an animal that has never been infected or vaccinated to an infected individual via contact of mucus membranes (e.g., licking an aborted fetus); or
- *vertically* from adult female to offspring via sharing of blood during the pregnancy or by subsequent nursing.

Abortion is the characteristic sign of acute brucellosis. Females may also suffer from a retained placenta and reduced milk production (Thorne 2001). Other signs for either sex include lameness, infertility, and swollen joints. Microscopic lesions may also occur in lymph nodes (Rhyan et al. 1994, Olsen et al. 1997).

Abortion is the characteristic sign of acute brucellosis.

Following pregnancy, the *Brucella* bacteria may become dormant, persisting only in cells of the lymphatic system (Cheville et al. 1998, Galey et al. 2005). The bacteria may lay dormant for a period, with acute infection possible during a later pregnancy (USDI and USDA 2000a, Galey et al. 2005). Appendix B provides greater detail on brucellosis infection, transmission, epidemiology, diagnosis, and pathology.

1.1.2 Disease Control via Vaccination

The most common tool for disease control in veterinary medicine has been vaccination (Appendix C), with success influenced by vaccine efficacy and the proportion of the population inoculated (Plumb et al. 2007). The primary goals of a vaccination program are to protect individuals from disease and reduce the transmission of the disease within the population by reducing the proportion of susceptible individuals (Shams 2005).

The primary goals of a vaccination program are to protect individuals from disease and reduce the transmission of the disease within the population by reducing the proportion of susceptible individuals.

Important factors to consider when evaluating the feasibility of a vaccination program are (1) the average age in which individuals are exposed to the disease, and (2) the duration of any acquired immunity. Vaccination is most effective when it occurs prior to the primary exposure period. Individuals must be revaccinated if duration of immunity is shorter than life expectancy. The process of attaining population immunity through vaccination is complicated when individuals acquire an infection through vertical exposure from the mother. Thus, the purpose of the vaccination program is to circumvent the infection process and move straight to acquired immunity through vaccine exposure (e.g., Figure 1).

Wildlife create substantial challenges for disease control because of limited knowledge regarding (1) how wildlife may react to vaccination, and (2) their distribution and mobility on the landscape. Also, few methods are available for delivery of vaccine to free-ranging populations (Wobeser 1994, Wobeser 2002).

1.2 Existing Condition

1.2.1 Interagency Bison Management Plan (IBMP) and Vaccination

A portion of the Yellowstone bison population periodically moves between habitats in the park and adjacent lands in Montana (Gates et al. 2005). Approximately 15 to 25% of the population is actively infected by brucellosis most years (Treanor et al. 2007b). Thus, cross-boundary movements result in a risk of interspecies transmission of brucellosis from Yellowstone bison to cattle on overlapping ranges adjacent to the park. In 2000, the NPS, State of Montana, Animal and Plant Health Inspection Service, and U. S. Forest Service signed the IBMP (also known as the Joint Management Plan) to coordinate bison management (USDI and USDA 2000a).

The interagency partnership evaluated alternatives for the IBMP in an FEIS, with the extent of the study area focusing primarily on Yellowstone National Park and adjacent areas in Montana. The purpose of the IBMP was to maintain a free-ranging population of bison while addressing the risk of brucellosis transmission to cattle in an effort to protect the economic interest and viability of the Montana livestock industry. The IBMP identified nine objectives for managing bison and the risk of brucellosis transmission to cattle. One of these objectives was to protect livestock from the risk of brucellosis infection. While the consequences of vaccination as a management tool were evaluated in the FEIS, the environmental consequences of a park-wide remote delivery vaccination program were not.

In addition to vaccination of bison via syringe at capture facilities, the 2000 ROD gave the park responsibility for developing an in-park, remote delivery vaccination program. The goal of the in-park vaccination program is to deliver a low risk, effective vaccine to eligible bison inside Yellowstone National Park to (1) decrease the risk of brucellosis transmission, and (2) diminish the overall seroprevalence of brucellosis in Yellowstone bison. Along with the development of a low risk and effective vaccine, this directive depended on the development of an effective remote delivery system.

> The Record of Decision gave the park responsibility for developing an in-park, remote delivery vaccination program.
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> **Seroprevalence**—the proportion of a population that has been exposed to brucellosis, as determined by the presence of antibodies in the blood of individual animals.

The IBMP, including remote delivery vaccination, “is not a plan to eradicate brucellosis” (USDI and USDA 2000b:6, 22). Instead, “it is a means to manage bison and cattle to minimize the risk of brucellosis transmission from bison to cattle” and “demonstrate a long-term commitment by the agencies to work towards the eventual elimination of brucellosis in free-ranging bison in Yellowstone National Park” (USDI and USDA 2000b:8).

The remote delivery vaccination program is part of a phased-in, adaptive management strategy described in the FEIS and ROD for the IBMP. Through adaptive

> The Interagency Bison Management Plan, including remote delivery vaccination, is not a plan to eradicate brucellosis.
>
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>
> At this time, eradication of brucellosis from wildlife in the greater Yellowstone ecosystem is more a statement of principle than a feasible action.

management, the IBMP is designed to progress through a series of management steps for bison tolerance (i.e., acceptance) on public land outside Yellowstone National Park during the winter when cattle are not present.

Initially, only bison testing negative for brucellosis will be tolerated; eventually limited numbers of untested bison will be tolerated. However, the implementation of a limited public hunt for bison by the State of Montana has already resulted in the state tolerating some untested bison outside Yellowstone National Park within the conservation area established by the IBMP (Montana Fish, Wildlife, and Parks and Department of Livestock 2004).

The 2000 ROD for implementation of the IBMP (USDI and USDA 2000b) directed IBMP partners to vaccinate bison at capture facilities in the IBMP bison management zones along the north and west park boundaries when a vaccine was shown to be safe. These criteria were met and a limited vaccination program has been sporadically implemented since January 2004. In some years, bison that no longer respond to hazing in park boundary areas are captured, tested for brucellosis exposure, and vaccinated if they test negative (calves five to 12 months of age and yearlings 13 to 24 months of age).

The 2000 ROD noted that vaccination-eligible bison are expected to initially include calves and yearlings of both sexes, and will also include adult female bison if and when the agencies deem a vaccine is low risk and effective. This decision document also stated that the agencies will deem a vaccine low risk and effective according to criteria established by the Greater Yellowstone Interagency Brucellosis Committee (Appendix D). The existing vaccination program was initiated after a review of study results showed that Strain RB51 (SRB51) met the safety criteria (Wallen and Gray 2003).

The partner agencies for the IBMP met several times in public venues during 2008 and 2009 to assess the effectiveness and outcomes of management activities during 2000-2009, and develop and incorporate short and long-term adaptive management actions based on prevailing conditions. On August 28-29, 2008, NPS staff distributed a briefing statement and provided a presentation to the IBMP partners and attending public on the Surveillance Plan for Bison in Yellowstone National Park. On October 15-16, 2008, NPS staff distributed a briefing statement and provided a presentation to the IBMP partners and attending public on the Vaccination of Yellowstone Bison. Copies of these statements, presentations, and meeting summaries that include comments from the public at the end of each meeting are posted on the world wide web at <www.ibmp.info>.

The most recent adaptive management agreement was signed by the partner agencies in December 2008. The adaptive management agreement will guide future operating procedures for the IBMP. As a result of the agreement, partner agencies will adjust bison abundance and distribution on lands adjacent to Yellowstone National Park based on evaluations of new conservation easements or land management strategies, reduced brucellosis prevalence in bison, and new information or technology that reduces the risk of disease transmission.

1.3 Purpose and Need

The purpose for taking action is to address NPS responsibilities as directed by the Joint Management Plan in the 2000 ROD. The need for remote vaccination is to (1) decrease fetal abortion events in bison due to a non-native disease, (2) reduce transmission of *Brucella abortus* among bison, (3) advance the IBMP to adaptive management step 3 where untested bison are allowed on essential winter ranges in Montana when cattle are not present (pursuant to the 2000 ROD), and (4) reduce the need for capture and large-scale (>1,000 bison) shipments to slaughter.

Expanding the current bison vaccination program will also protect livestock from the risk of brucellosis infection, which would help to increase acceptance for bison that have not been tested for brucellosis outside Yellowstone National Park. The FEIS and ROD for the IBMP indicate that the release of untested bison outside Yellowstone National Park is linked to the initiation of a remote delivery vaccination program for bison in the park.

The following statements from the IBMP further establish the need for remote vaccination:

- The NPS must "maintain a wild, free-ranging population of bison" (USDI and USDA 2000b:36); and
- The NPS does not intend to conduct extensive capture operations inside the park to handle most individual bison and deliver vaccine because "extensive capture operations, as well as confinement to the park, might detract from the wild free-ranging qualities of the bison population" and "could have a major adverse impact on the distribution of bison" (USDI and USDA 2000a:415; see also 421-422).

Therefore,

- The NPS will conduct a remote vaccination program of vaccination-eligible bison within the park to allow a limited number of untested bison on winter range lands outside the park" (USDI and USDA 2000b:37); and
- The vaccination program should contribute "to the eventual elimination of brucellosis from the Yellowstone bison herd" and "seropositive rates cannot remain as they are or increase, but must decrease over the life of the plan" (USDI and USDA 2000b:36, 57).

Because vaccination is most effective when it occurs prior to primary exposure and because exposure from the mother will complicate the process of attaining population immunity, offspring need to be the initial focus for vaccination.

Therefore,

- The 2000 ROD stated that vaccination-eligible bison are expected to initially include calves and yearlings of both sexes and will also include adult female bison if and when the agencies deem a vaccine low risk and effective according to criteria established by the Greater Yellowstone Interagency Brucellosis Committee.

The alternatives analyzed in the EIS should meet the following objectives:

1. Preserve the essential ecological process of migration across the park boundary to facilitate the long-term conservation of bison in this temperate mountain environment.
2. Decrease the probability of individual bison shedding field strain *B. abortus*.
3. Lower the brucellosis infection rate of Yellowstone bison (as established in the desired outcome).

4. Test, monitor, and adjust for a safe, effective, low-risk, in-park remote delivery system for vaccination-eligible bison within the park.

The desired outcome from the remote vaccination program is a 50% decrease in brucellosis seroprevalence from the low end of the current state (i.e., 40–60%), which would decrease seroprevalence to approximately 20% and, based on Roffe et al. (1999), the level of active infection to approximately 10%.

The ROD also states that "[a]dditional NEPA [National Environmental Policy Act] analysis would also occur prior to initiating a park-wide, remote vaccination program" (USDI and USDA 2000b:54). This EIS is intended to satisfy that commitment and result in a decision on whether to proceed with the implementation of remote delivery vaccination of bison throughout Yellowstone National Park.

1.4 Scope of the EIS

This EIS analyzes the potential impacts to the natural and human environment from implementing an in-park, remote delivery, vaccination program for brucellosis in free-ranging bison in Yellowstone National Park. The analysis area for the in-park, remote, vaccination program includes the area of bison distribution in the park (Figure 2). The proposed alternatives described in this analysis rely on the adaptive management paradigm for achieving results and making iterative adjustments by: 1) developing predictions based on modeling of alternatives; 2) implementing management actions with subsequent monitoring; 3) adjusting management actions as necessary based on the monitoring results; and 4) new monitoring resulting in possible new management action adjustment, and so on (see Chapter 2 for further explanation).

The decision from this analysis will be tiered from the decisions contained in the ROD for the IBMP FEIS. Thus, this EIS is not intended to revisit the IBMP or revise decisions already made in the ROD. The proposed action should provide timely and useful information to help develop adaptive management adjustments needed to conserve Yellowstone bison (e.g., more tolerance outside the park) and reduce the prevalence of brucellosis in the bison population. Results of remote delivery vaccination should provide managers with the knowledge needed to more effectively reduce the risk of brucellosis transmission among bison and from bison to other species. Additionally, the results will help address key uncertainties regarding the potential for brucellosis suppression, vaccine efficacy, and vaccine delivery through surveillance activities (White et al. 2008).

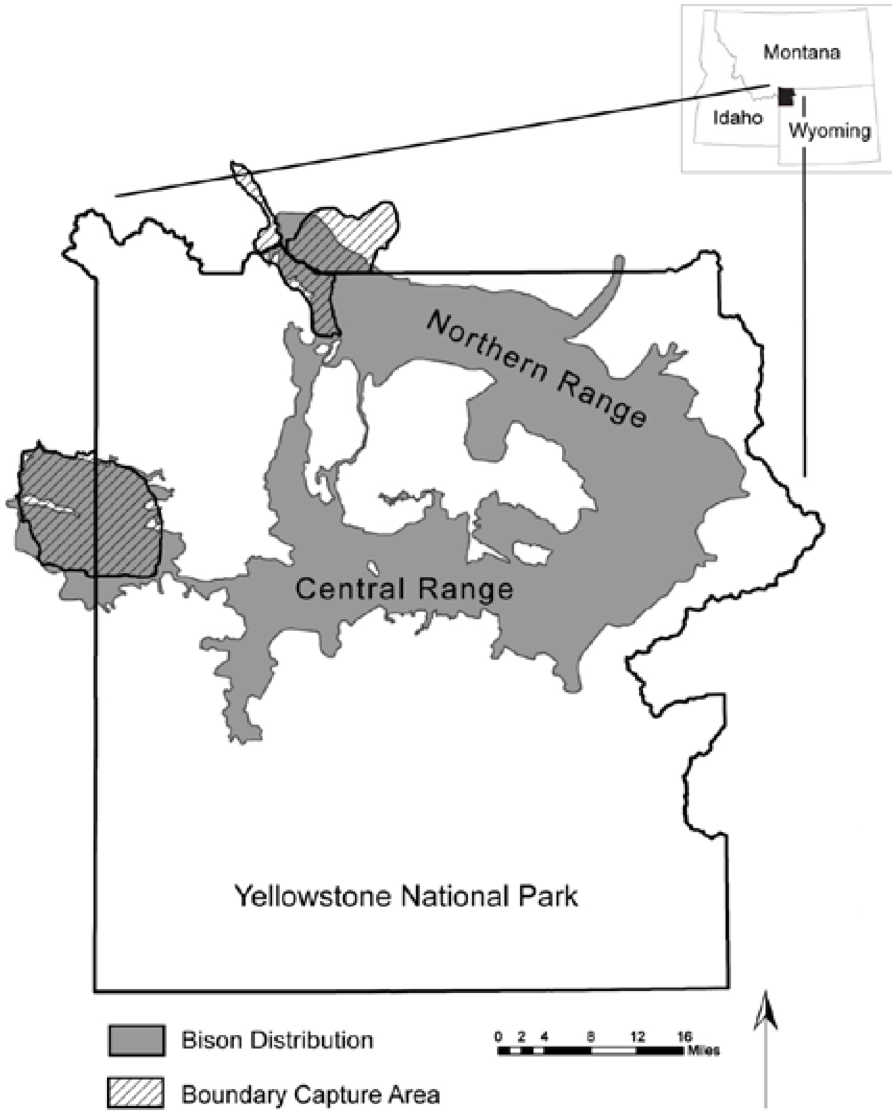

Figure 2. EIS analysis area.

1.5 Park Establishment, Mission, and Management

Yellowstone National Park was established as the first park in the national park system in 1872. Under the Yellowstone Park Act, 2.2 million acres of wilderness were "set apart as a public park or pleasuring ground for the benefit and enjoyment of the people." Preserved within Yellowstone National Park are Old Faithful and the majority of the world's geysers and hot springs. An outstanding mountain wildland with clean water and air, Yellowstone National Park is home to the grizzly bear (*Ursus arctos*), wolf (*Canis lupus*), and free-ranging herds of bison and elk. Centuries-old sites and historic buildings that reflect the unique heritage of America's first national park are also protected.

Yellowstone National Park serves as a model and inspiration for national parks throughout the world. The NPS preserves these and other natural and cultural resources and values unimpaired for the enjoyment, education, and inspiration of present and future generations (1916 Organic Act, 1978 Redwoods Act, National Park Omnibus Management Act of 1998).

Because bison are an essential component of the Yellowstone ecosystem, impacts to the preservation of this wild population can have a cascading impact on other park resources, both plants and animals. Few other species of wildlife are so intertwined in the ecological and social aspects of human culture in the greater Yellowstone ecosystem (GYE). The cultural values that bison represent are important components of the oral histories of the 26 American Indian tribes associated with Yellowstone National Park. In addition, bison represent a symbol of the vast wilderness that once was the western plains and prairie landscape. They are an icon for strength, courage, and determination. Given these attributes, world-wide interest exists for conservation of Yellowstone bison (Danz 1997, Rudner 2000, Cromley 2002, Franke 2005).

> The Organic Act of 1916 directs the U.S. Department of Interior and National Park Service to manage units of the national park system "to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."

> Bison are an essential component of Yellowstone ecosystem processes. Few other species of wildlife are so intertwined in the ecological and social aspects of human culture in the Greater Yellowstone Ecosystem.
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> Bison represent a symbol of the vast wilderness that once was the western plains and prairie landscape. They are an icon for strength, courage, and determination.

1.6 Legal and Policy Framework

The legal framework for the decision resulting from this EIS is defined by the enabling legislation for Yellowstone National Park and NPS policy (NPS 2006). Other relevant legal and regulatory guidance includes, among many, the 1916 Organic Act, 1978 Redwoods Act, National Park Omnibus Management Act of 1998, Endangered Species Act, and Executive Order 13175 Consultation with Indian Tribal Governments of 2000. The alternatives in this EIS have been designed to comply with all legislative requirements and policy directives. These key pieces of legislation and policy are described in more detail in Appendix E.

The NPS Organic Act of 1916 directs the USDI and NPS to manage units of the national park system "to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (16 U.S.C. 1). Congress reiterated this mandate in the Redwood National Park Expansion Act of 1978, which states that the NPS must conduct its actions in a manner that will ensure no "derogation of the values and purposes for which these various areas have been established, except as may have been or shall be directly and specifically directed by Congress" (16 U.S.C. 1a-1).

NPS Management Policies 2006 (NPS 2006) set the framework and provide policy direction for decision-making in the administration of the NPS and its programs. Park planning is conducted primarily through Strategic Plans and project planning documents. The Master Plan of 1974 and

Statement for Management in 1991 for Yellowstone National Park guide application of the NPS Management Policies 2006. These two directives require the protection of ecological processes and native species in a relatively undisturbed environment.

Areas of policy applicable to this planning effort include (1) animal population management, (2) protection of native animals, and (3) removal of exotic species already present (NPS 2006). Policy directs the NPS to minimize human impacts on native plants and animals with respect to their populations, the communities and ecosystems in which they live, and the natural processes which they influence. Thus, whenever possible, NPS managers should rely on natural processes to maintain native plant and animal species, and to influence natural fluctuations in populations of these species. Furthermore, managers should prevent the introduction of exotic species and develop plans to manage these species where they are already established.

Director's Orders may prescribe supplemental operating policies to the Management Policies 2006. These orders may provide specific instructions, requirements, or standards applicable to NPS functions, programs, and activities, as well as delegate authority and assign responsibilities.

Director's Order #12 (DO-12): Conservation Planning, Environmental Impact Analysis and Decision-making and its implementing handbook (NPS 2009a) direct the planning process under the National Environmental Policy Act (NEPA). The purpose of NEPA planning is to ensure that federal agencies consider the environmental costs relative to the benefits of proposed actions. The USDI has codified and amended policies and procedures for compliance with NEPA (73 Federal Register 61292-61323).

> Whenever possible, National Park Service managers should rely on natural processes to maintain native plant and animal species, and to influence natural fluctuations in populations of these species.

Natural Resource Management Reference Manual #77 offers comprehensive guidance to National Park Service employees responsible for managing, conserving, and protecting the natural resources found in National Park System units. This Reference Manual interprets USDI and NPS policies pertaining to management of natural resources, including wildlife and non-native species.

1.7 Park Planning and Other Policies and Plans

Park planning is conducted primarily through Strategic Plans and project planning documents. The Master Plan of 1974 and Statement for Management in 1991 for Yellowstone National Park guide application of the NPS Management Policies 2006 (NPS 2006). These directives require the protection of ecological processes and native species in a relatively undisturbed environment.

The Interagency Bison Management Plan was completed in December 2000 with resultant federal and state of Montana RODs. One objective of the IBMP is to protect livestock from the risk of brucellosis transmission from bison. To achieve this objective, the IBMP declared vaccination as a management action for reducing brucellosis seroprevalence in bison and, thus, reducing transmission of brucellosis from bison to bison and from bison to cattle. The FEIS (USDI and USDA 2000a:473) and federal ROD for the IBMP (USDI and USDA 2000b:10-13) envisioned a progression of bison vaccination activities to reduce the risk of brucellosis transmission, and serve as an initial step towards the eventual elimination of brucellosis from the bison population. The projected process was to begin vaccinating all eligible bison captured at the park boundary that would be subsequently released. This action would be followed by remote vaccination of untested, eligible bison outside the park in the western boundary area to assess the effectiveness of this delivery method. Finally, all eligible bison inside and outside Yellowstone National Park would be vaccinated to reach a whole-herd vaccination goal.

The Interagency Bison Management Plan declared vaccination as a management action for reducing the seroprevalence rate in bison and, thus, reducing transmission of brucellosis from bison to bison and from bison to cattle.

Though implementation of the IBMP has greatly reduced the risk of brucellosis transmission from bison to cattle (Kilpatrick et al. 2009), there is no evidence that it has contributed to a reduction in brucellosis exposure or infection within the bison population (Hobbs et al. 2009). Progress has been slower than anticipated at completing the plan's successive adaptive management steps designed to increase tolerance for bison outside the park and decrease brucellosis seroprevalence (U.S. Government Accountability Office 2008). With the exception of 2001, 2004, and 2005, bison migrating outside the park were not consistently captured and tested for brucellosis, with test-positive bison sent to slaughter and test-negative bison vaccinated. Instead, bison near the north boundary that no longer responded to hazing were often captured and, without testing, either sent to slaughter or held without vaccination for release back into the park during spring. Additionally, remote delivery vaccination of bison has not been implemented outside the west boundary of the park. To improve progress, the IBMP agencies approved adaptive management adjustments in 2008 that further described the circumstances for bison occupying habitats outside the park, established a precedent for minimizing consignment of bison to slaughter, re-affirmed the commitment to vaccinating bison, developed a method for sharing decision documents with public constituencies, and developed a metric for annual monitoring of and reporting on IBMP actions (USDI et al. 2008).

There are other policies and plans, including those in preparation, that relate to the management of bison in the GYE (Table 1). These planning efforts involve the NPS, other federal agencies, and state management agencies. The NPS generally does not have jurisdiction over state or other federal agency management strategies, decisions, or actions outside park boundaries.

1.8 Appropriate Park Uses

Sections 1.4 and 1.5 of Management Policies (NPS 2006) direct that the NPS ensure that allowed uses of the park will not cause impairment of, or unacceptable impacts on, park resources and values. A new form of park use may be allowed only after the park manager has determined such impairment or impacts will not occur.

Section 8.1.2 of Management Policies (NPS 2006), Process for Determining Appropriate Uses, provides evaluation factors for determining appropriate uses. All proposals for park uses are evaluated in five areas:

- consistency with applicable laws, executive orders, regulations, and policies;
- consistency with existing plans for public use and resource management;

- actual and potential effects on park resources and values;
- total costs to the NPS; and
- whether the public interest will be served.

Park managers must continually monitor all park uses (existing and new) to prevent unanticipated and unacceptable impacts. If unanticipated and unacceptable impacts emerge, the park manager must engage in a thoughtful, deliberate process to further manage, newly constrain, or discontinue the use. More information on the definition of unacceptable impacts as cited in §1.4.7.1 of Management Policies (NPS 2006) can be found in Chapter 4—Environmental Consequences.

Table 1. Relationships to other plans and documents

Year	Plan/Document	Description	Requirements
2000	Interagency Bison Management Plan for the State of Montana and Yellowstone National Park	Separate Records of Decision signed at federal and state levels.	Interagency Bison Management Plan directed remote vaccination as a Step 3 initiative contingent on further environmental compliance.
2003	Subcutaneous Vaccination of Wild, Free-ranging Bison in the Greater Yellowstone Area Environmental Assessment and Finding of No Significant Impact	Prepared by Animal and Plant Health Inspection Service. Environmental Assessment for vaccination program in the area outside the western boundary of the park.	Authorized employees of the Animal and Plant Health Inspection Service to participate in hand-vaccination operations throughout the Greater Yellowstone Ecosystem, as appropriate.
2004	Final Bison Hunting Environmental Assessment	Prepared by Montana Fish, Wildlife and Parks. Assesses limited hunting for bison in Montana outside the park.	Decision Notice in September 2004 authorizing a fair-chase bison hunt limited to areas outside the park where direct hazing is not occurring under Interagency Bison Management Plan.
2004	Bison Vaccination Environmental Assessment	Prepared by Montana Department of Livestock. Proposed vaccination of seronegative bison calves and yearlings outside the western boundary of the park.	Decision Notice in February 2005 authorized vaccination of calves and yearlings as directed in the IBMP, in the Western Special Management Area.
2004	Bison Quarantine Feasibility Study – two separate Environmental Assessments completed to describe separate phases of the program	Prepared by Montana Fish, Wildlife and Parks and the Animal and Plant Health Inspection Service.	Decision Notices in January of 2005 and June of 2006 authorizing a study to validate the quarantine protocol proposed in Appendix B of Interagency Bison Management Plan.
2007	Final Bison and Elk Management Plan and EIS for the National Elk Refuge and Grand Teton National Park	Prepared by the National Elk Refuge and Grand Teton National Park. Guides bison and elk management in Jackson Hole and addresses brucellosis management in those populations.	Decision Notice in April 2007 authorized a reduction in bison numbers from >1,100 to 500 via hunting and a progressive reduction in supplemental feeding.
2008	Purchase of a conservation easement on the Royal Teton Ranch – an Environmental Assessment	Prepared by Montana Fish, Wildlife and Parks.	Decision Notice in December 2008 to purchase a livestock grazing restriction that opened part of the northern zone 2 of the Interagency Bison Management Plan for some bison to occupy during winter.
2008	Bison Translocation Environmental Assessment - Quarantine Phase 4	Prepared by Montana Fish, Wildlife and Parks.	Decision Notice in March of 2009 authorizing translocation and release of 41 disease-free Yellowstone bison to the Northern Arapaho Nation of the Wind River Reservation in Wyoming.

The remote vaccination of eligible bison is consistent with existing plans and policies. Vaccination as a management tool was established in the IBMP as a means to reduce the risk of brucellosis transmission among bison. While NPS policy does not specifically mention vaccination, it does allow for "animal population management." Subsequently, use of vaccines for wildlife management and conservation purposes is not a new practice in National Park Service units. Contraceptive vaccines have been used in a variety of national park units since the 1970s (Matschke 1980, Kirkpatrick et al. 1997, Fagerstone et al. 2002). Other units have conducted similar vaccination programs on free-ranging wild animals to control abundance of horses (Assateague Island National Seashore), feral donkeys (Virgin Islands National Park), Tule elk (*Cervus elaphus nannodes*; Point Reyes National Seashore), and white-tailed deer (*Odocoileus virginianus*; Fire Island National Seashore). Draft Director's Order 77-4 provides guidance on use of fertility control vaccination for wildlife populations.

The remote vaccination of eligible bison with an effective and low risk vaccine would result in reduced transmission of the disease among bison. Thus, it could be an important step towards suppression and eventual elimination of the bacteria from the Yellowstone bison population.

The development of effective vaccines and the use of mass immunization has been a successful approach in combating infectious diseases of humans and domestic animals (Pastoret et al. 2007). Thus, there is no reason to think that immunization of wild animals could not be effective at controlling the spread of infectious diseases if appropriate vaccines are available and can be delivered to the populations in need (Wobeser 2002). Many of the strategies used to manage wildlife diseases are complicated because it is impractical to capture and treat all individuals of a population. Therefore, management of wildlife diseases is limited to those infectious diseases that are zoonotic (e.g., those that can affect humans and their domestic animals) in nature.

By meeting the requirements of the IBMP, this action is also consistent with NPS Management Policies (2006, Chapter 1.6). Cooperative conservation beyond park boundaries is necessary as the National Park Service strives to fulfill its mandate to preserve the natural and cultural resources of parks unimpaired for future generations. Many ecological processes cross park boundaries, and park boundaries may not incorporate all of the natural resources, cultural sites, and scenic vistas that relate to park resources or the quality of the visitor experience. Therefore, activities proposed for implementation on adjacent lands may have significant affects on park resources and values. Conversely, NPS activities may have impacts beyond our boundary. Recognizing that parks are integral parts of larger regional environments, and to support its primary concern of protecting park resources and values, the NPS will work cooperatively with others to (1) anticipate, avoid and resolve potential conflicts, (2) protect park resources and values, (3) provide for visitor enjoyment, and (4) address mutual interests in the quality of life for community residents, including matters such as compatible economic development and resource and environmental protection (NPS 2006).

Low elevation winter range is limited both inside and outside Yellowstone National Park. The negotiated settlement (i.e., IBMP) between the National Park Service and the State of Montana recognized that cooperative management of bison was necessary since no agency has sole jurisdiction for bison throughout the conservation area. The IBMP noted that the NPS would implement an in-park vaccination program for bison and, in turn, the state of Montana would be more flexible in allowing an expansion of the conservation area to include the Horse Butte peninsula west of Yellowstone National Park and the Gardiner Basin to the north.

Therefore, remote vaccination is consistent with applicable laws and policies and the IBMP, and the public interest is served by maintaining a wild, free ranging bison herd. Costs for vaccination were previously analyzed in the FEIS for the IBMP and further impact analysis is disclosed in this EIS. Thus, the NPS finds that remote delivery vaccination for bison is an appropriate use at Yellowstone National Park.

NPS finds that the use of a remote delivery vaccination program for bison is an appropriate use at Yellowstone National Park.

1.9 Public Scoping

Public scoping for the remote bison vaccination program was initiated on August 3, 2004, when the Notice of Intent to Prepare an EIS was published in the Federal Register (69 FR 46564). Public scoping newsletters were mailed to 155 individuals, organizations, and interested parties in August 2004. The public scoping newsletter provided information on the scope, purpose and need, description of the proposed action, and the process for providing comments, including dates and times for planned open house meetings. The newsletter also included instructions on how to submit comments by mail, facsimile, e-mail, and an automated comment form on the project website. The public was encouraged to provide their comments by October 2, 2004.

In addition, announcements for the open house meetings were published in six local newspapers, including the Bozeman Daily Chronicle, Billings Gazette, Cody Enterprise, West Yellowstone News, Jackson Hole Guide, and Associated Press Livingston Enterprise. A project webpage was set up on the park website that contained the scoping schedule. Open house meetings were held during the week of September 12, 2004. Four regional locations were selected for these meetings so that various interested parties could participate. The schedule for the public scoping open house meetings was as follows: 1) Gardiner, Montana on September 13, 2004; 2) Bozeman, Montana on September 14, 2004; 3) Idaho Falls, Idaho on September 15, 2004; and 4) Cody, Wyoming on September 16, 2004. Representatives from the park's Bison Ecology and Management Program and Greystone Environmental Consultants attended and helped facilitate all four public scoping meetings.

A total of 126 comment documents were received during the public scoping period. The majority of these letters were received via e-mail, U.S. mail, and comment forms collected at the open houses. In addition, 11 individuals provided comments using the project website. More than 800 specific comments—both substantive and non-substantive—were tallied within the 126 documents. Substantive comments were those that identified potential issues or offered reasonable alternatives for the proposed project. The non-substantive comments did not identify issues or provide suggestions, but discussed issues outside of the scope of the proposed vaccination program. Of the comments received, 57% were considered substantive and related to the analysis while 37% were not. Another 6% were deemed not

Public scoping for the bison vaccination program was initiated on August 3, 2004. Open house meetings were held during the week of September 12, 2004, at four regional locations:

1) Gardiner, Montana;
2) Bozeman, Montana;
3) Idaho Falls, Idaho; and
4) Cody, Wyoming.

applicable to the scoping process. Also included were requests for further information, future mailings, and copies of future documents. All comments were entered into a digital database. Each comment from an individual or group was assigned an identification code for tracking.

Several potentially relevant issues and concerns were identified by the NPS interdisciplinary team and through public scoping. A Public Scoping Summary was completed in December 2004 and is incorporated by reference. These issues were used to formulate impact topics developed from the analysis of these comments (Table 2).

1.10 Impact Topics Carried Through the Analyses

Many potentially relevant issues and concerns were identified through (1) the public scoping process, (2) an NPS internal interdisciplinary team, and (3) on the basis of federal laws, regulations, orders, and NPS Management Policies 2006 (NPS 2006) (Table 2).

1.10.1 Yellowstone Bison Population

The bison population is the key resource that may be affected by proposed actions. Free-ranging bison within the park must be protected so that they continue to serve their functional role in ecosystem processes.

Many constituencies reject the idea of active management of any kind to reduce the prevalence of brucellosis in the Yellowstone bison population. In addition, much debate has occurred over the appropriateness of vaccinating free-ranging wildlife in a national park. While vaccination is legal and likely both feasible and useful in wildlife disease management, some interest groups reject the idea. Those opposing vaccination cite many concerns, including a belief that vaccination is an inappropriate management tool in a national park, negative effects of disturbance to wildlife, and conflicts with their personal values. Conversely, livestock regulatory and disease control agencies have supported the concept of vaccination in multiple venues.

The effectiveness of strain RB51 (SRB51) vaccine against field strain *B. abortus* is not conclusive and mixed results have been reported by various research projects. The USDA–Agricultural Research Service has published results of research showing that only 15% of vaccinated bison aborted pregnancies when experimentally challenged by a virulent strain of *B. abortus*, while 62% of non-vaccinates aborted their pregnancies (Olsen et al. 2003). Conversely, experiments conducted by Texas A&M University concluded that vaccination with SRB51 provides no protection from aborted pregnancies (Elzer et al. 2000). The results are not comparable because methods were not consistent. However, the Scientific Advisory Subcommittee on Brucellosis United States Animal Health Association, which includes the authors of these two disparate studies, has reviewed these studies and concluded in 2008 that experimental data for hand vaccination of bison with Strain RB51 suggests a 50-60% reduction in abortions, 45-55% reduction in infection of uterine or mammary tissues, and a 10-15% reduction in infection. Furthermore, the Subcommittee concluded that currently available data suggests remote delivery induces protection that is less than hand vaccination.

1.10.2 Other Wildlife

The topography and vegetation in Yellowstone National Park provide habitat for a wide range of wildlife species. Wildlife populations, including pronghorn (*Antilocarpa americana*), mule deer (*Odocoileus hemionus*), elk, and a variety of predators and scavengers could be affected by the vaccination of bison.

Table 2. Environmental issues and corresponding impact topics

Description of environmental or other issues	Corresponding chapter (section) where Issue and/or Impact is discussed
Scientific evidence to support transmission of brucellosis between bison and cattle.	Chapter 1 (Introduction); Appendix B (Brucellosis)
Effectiveness of vaccines.	Chapter 4 (Incomplete and Unavailable Information); Appendix C (Vaccination); Appendix D (Safety and Efficacy Criteria for Bison Vaccines Against Brucellosis)
Safety and effectiveness of delivery methods.	Chapter 4 (Incomplete and Unavailable Information)
Modeling the probability that a vaccination program will successfully decrease the rate of brucellosis in bison.	Chapter 4 (Impacts to Yellowstone Bison)
Effective immunity against challenge with an infectious *Brucella* pathogen.	Chapter 2 (Alternatives Considered But Eliminated From Further Consideration); Chapter 4 (Incomplete and Unavailable Information); Appendix C (Vaccination)
How to approach bison and not disturb group dynamics and behavior.	Chapter 2 (Alternatives Considered But Eliminated From Further Consideration); Chapter 4 (Impacts to Yellowstone Bison – Alternative B)
Natural means of managing wildlife.	Chapter 2 (Alternatives Considered But Eliminated From Further Consideration); Chapter 4 (Impacts to Yellowstone Bison – Alternative B); Appendix E (Compliance with Federal or State Regulations)
Visitor and aesthetic experience.	Chapter 3 (Visitor Use and Experience); Chapter 4 (Visitor Use and Experience)
Human health and safety.	Chapter 3 (Human Health and Safety); Chapter 4 (Human Health and Safety)
Impacts to environment.	Chapter 4 (Impacts to Yellowstone Bison); Chapter 4 (Other Wildlife, Including Threatened Species)
NPS responsibility under the Organic Act of 1916 and National Environmental Policy Act.	Appendix E (Compliance with Federal or State Regulations)
American Indian tribal concerns and consultation.	Chapter 3, section on "Ethnographic Resources;" Chapter 4, section on "Ethnographic Resources;" Appendix E (Compliance with Federal or State Regulations)
The appropriateness of vaccinating wildlife against non-native diseases in national parks.	Appendix C (Vaccination)

1.10.3 Threatened/Endangered/Sensitive Species

The Endangered Species Act of 1973, as amended, mandates that federal agencies consider the potential effects of their actions on species listed as threatened or endangered. Section 7 of the Act requires that a federal agency consult with the U.S. Fish and Wildlife Service (USFWS) or the National Marine Fisheries Service on any action that may affect species or result in modification of critical habitat. Yellowstone National Park is occupied by the federally listed, threatened Canada lynx, gray wolf, and grizzly bear. Also, the bald eagle and peregrine falcon were recently removed from the Federal List of Endangered and Threatened Wildlife and Plants. The Bald Eagle Protection Act of 1940 still provides for the protection of the bald eagle and the golden eagle by prohibiting, except under certain specified conditions, the taking, possession, and commerce of such birds. Consultation on these species with respect to the current EIS occurred with the USFWS and concurrence for NPS to proceed was received in January 2007.

> Yellowstone National Park is occupied by the federally listed, threatened Canada lynx, gray wolf, and grizzly bear. Also, the bald eagle and peregrine falcon were recently removed from the Federal List of Endangered and Threatened Wildlife and Plants. Consultation on these species with respect to the current Environmental Impact Statement occurred with the U.S. Fish and Wildlife Service and concurrence for the National Park Service to proceed was received in January 2007.

1.10.4 Ethnographic Resources

The National Historic Preservation Act of 1966, as amended, NEPA, the 1916 Organic Act, the NPS Management Policies 2006 (NPS 2006), and other NPS guidelines require consideration of impacts to cultural resources. Proposed project undertakings have the potential to affect ethnographic resources. Yellowstone National Park regularly consults with 26 associated American Indian tribes that consider bison culturally significant to their heritage. An additional 83 tribes have attended some consultations and stated to park officials that they also consider bison a significant part of their culture.

1.10.5 Human Health and Safety

A concern exists that contact with the brucellosis vaccine could have a negative effect on human handlers and on humans that encounter carcasses of vaccinates. In addition, waste associated with vaccines and certain delivery methods could be hazardous to humans and the environment. *Brucella abortus* is considered a controlled chemical substance or hazardous material under some federal classification systems.

Some vaccinated bison will likely migrate to hunting districts where Montana-licensed and tribal hunters harvest a small proportion of the Yellowstone bison population each year. It takes about 21 days for SRB51 vaccine to clear an animal's system. Thus, meat from animals vaccinated with SRB51 should not be consumed at least until after this time period has elapsed. Mitigation measures will be implemented to vaccinate in areas distant from areas with impending or ongoing hunting to avoid or minimize human health concerns regarding the harvest of recently vaccinated bison. Thus, there will be little to no direct contact by hunters with vaccinated bison under any of the proposed alternatives.

1.10.6 Visitor Use and Experience

The 1916 NPS Organic Act and the NPS Management Policies 2006 (NPS 2006) direct national parks to provide for public enjoyment. The presence of bison in the park directly affects the experience of park visitors because it allows them to view one of the natural resources for which the park was created. Some visitors may hold deeply rooted values that management actions to manipulate wildlife in national parks should not be undertaken. Therefore, vaccination activities could impact visitor experience.

1.10.7 Park Operations

Park operations include aspects of maintenance, law enforcement, emergency response, interpretation and education, and natural and cultural resource management. Programs such as wildlife management and park procedures related to natural resources could be affected by the proposal due to increased staff duties in providing field logistics, coordination with contractors for supplies and materials, and filling information requests by interested parties.

1.11 Topics Dismissed from Further Consideration

Council on Environmental Quality regulations (40 Code of Federal Regulations [CFR] Parts 1500-1508) and DO-12 require that certain topics be addressed in an EIS. Topics may be dismissed from analyses if the resource is not present or the impacts are anticipated to be minor or less. The following topics are not analyzed in this EIS for the reasons stated below.

1.11.1 Environmental Justice

Executive Order 12898—General Actions to Address Environmental Justice in Minority Populations and Low-Income Populations—requires all federal agencies to incorporate environmental justice into their missions. Agencies must identify and address disproportionately high and adverse human health or environmental effects of their programs and policies on minorities and low-income populations and communities. This topic was adequately addressed in the FEIS for the IMBP in the "Impacts to Socioeconomics" section and the NPS incorporates that analysis by reference (USDI and USDA 2000a).

Federal agencies must also follow rules set under the Environmental Justice Guidance released by the Environmental Protection Agency in 1998. None of the alternatives proposed in this EIS regarding remote delivery vaccination of Yellowstone bison would have disproportionate adverse health or environmental effects on minorities or low-income populations or communities as defined in this Environmental Protection Agency guidance.

1.11.2 Socio-economics

The social and economic implications of implementing the IBMP, including the costs and benefits of bison vaccination, were evaluated and disclosed in the FEIS completed for the IBMP and are incorporated by reference in this EIS (USDI and USDA 2000a). In 2000, the agencies estimated that the annual cost to implement an in-park vaccination program would be $330,500 (USDI and USDA 2000a:548). Also, additional information is disclosed in this EIS regarding the estimated costs of implementing remote delivery vaccination (Appendix F, Table F1). The implementation of remote delivery

> The implementation of alternatives B and C would cost approximately an additional $9 million dollars over 30 years (not adjusted for inflation) for remote delivery vaccination, likely implemented with federal funding.

vaccination would cost approximately an additional $9 million dollars over 30 years for remote delivery vaccination, likely implemented with federal funding. This initiation of remote delivery vaccination inside Yellowstone National Park is supposed to result in increased tolerance for untested bison on winter range lands outside the park in the northern boundary area (USDI and USDA 2000b:28). Adaptive adjustments to the IBMP (USDI et al. 2008) already allow for a greater tolerance of untested bison on the Horse Butte peninsula outside the western boundary of Yellowstone National Park because cattle are no longer present there during winter and spring.

In addition, Yellowstone National Park plays a large economic role in the tourism industry of the GYE, with visitors to the park providing substantial economic activity to surrounding gateway communities. Total visitor spending in 2006 within 150 miles of Yellowstone National Park was estimated at $271 million, which supported approximately 4,952 full and part-time jobs and generated $336 million in combined visitor and workforce sales, $133 million in labor income (e.g., wages, salaries, payroll benefits), and $201 million in value added (e.g., labor income plus profits, rents, and sales and excise taxes; Stynes 2008). Over 90% of visitors indicated that Yellowstone National Park was the primary reason for their trip to the area (Stynes 2008).

The actions described in this EIS for remote vaccination delivery to Yellowstone bison are unlikely to reduce the seroprevalence of brucellosis in wildlife sufficiently (i.e., near zero) to alter the perceptions of livestock operators, producers, and regulators regarding the risk of brucellosis transmission to cattle from wildlife. For bison, it is unlikely that the remote delivery vaccination actions will reduce the seroprevalence of brucellosis from current levels of 40-60% to below 16% (see Chapter 4, Impacts to Yellowstone Bison). Even if that were to be achieved, the State of Montana and the livestock industry are currently concerned about single-digit seropositive values in elk populations managed by the state—which are not under consideration in this EIS for vaccination—due to apparent brucellosis transmission from elk to cattle during 2007 and 2008. Thus, brucellosis will remain a concern for the livestock industry regardless of the outcome of a remote delivery vaccination program for Yellowstone bison and, thus, such a program would likely have negligible impacts on social and economic factors affecting the livestock industry.

Public constituencies are divided regarding their opinions about bison management in the Yellowstone bison conservation area (Duffield et al. 2000a, b). A portion of that debate centers on vaccination and its relationship to the elimination of brucellosis from the GYE. Also, many people either strongly agree or disagree that vaccination is a socially acceptable method for managing wildlife disease in national parks. This debate is further compounded because vaccination procedures are socially more acceptable to public constituencies than large-scale culling (e.g., depopulation, test-and-slaughter; Cheville et al. 1998). Further, it is unlikely these massive animals would be well tolerated in most areas outside Yellowstone National Park even if they were disease-free due to social and political barriers such as human safety concerns (e.g., motorists), conflicts with private landowners (e.g., property damage), depredation of agricultural crops (grass for livestock), competition with livestock grazing, lack of local public support, and lack of funds for state management (Boyd 2003, Plumb et al. 2009). Given these issues were adequately addressed, and the information is still valid, in the FEIS for the IMBP in the “Impacts to Socioeconomics” section and the NPS incorporates that analysis by reference (USDI and USDA 2000a), further analysis in this EIS was not included.

1.11.3 Possible Conflicts with Land Use Plans, Policies or Controls

Since the proposed remote vaccination program will be conducted within park boundaries, and is meeting a requirement of the IBMP, no conflict with local, state, or Indian tribe land use plans, policies, or controls will occur.

1.11.4 Archeological Resources

The NPS Cultural Resource Management Guideline (NPS 1998) defines archeological resources as the remains of past human activity and records documenting the scientific analysis of these remains. The proposed vaccination delivery program is not anticipated to involve sub-surface ground disturbance. The surface disturbance of the undertaking would be similar to the natural movements of humans and animals across the landscape. Following guidance in the National Historic Preservation Act, Section 106, consultation with both the Wyoming and Montana State Historic Preservation Offices was completed with concurrence letters received in December 2006 (Appendix G).

1.11.5 Historic Structures

The NPS Cultural Resource Management Guideline (NPS 1998) defines (historic) structures as material assemblies that extend the limits of human capability. There are several significant historic structures within Yellowstone National Park. However, none of the alternatives would affect these structures.

1.11.6 Cultural Landscapes

The NPS Cultural Resource Management Guideline (NPS 1998) defines cultural landscapes as settings that humans have created in the natural world. Potential cultural landscapes in the form of the park's primary road system, structures, and bridges include the historic Buffalo Ranch in the Lamar Valley, Old Faithful, Fishing Bridge, and Fort Yellowstone/Mammoth Hot Springs (Yellowstone National Park 1999). However, none of the alternatives would affect these cultural landscapes.

1.11.7 Museum Collection

Museum objects are manifestations and records of behavior and ideas that span the breadth of human experience and depth of natural history (NPS 1998). No museum objects would be affected by the alternatives.

1.11.8 Indian Trust Resources

Indian trust resources are land, water, minerals, timber, or other natural resources that are held in trust by the United States for the benefit of an Indian tribe or individual tribal member. Prior to, and during the course of drafting and releasing the Final Environmental Impact Statement for the Interagency Bison Management Plan (USDA and USDI 2000), the agencies conducted government-to-government consultations with Native American tribes, as described in volume 1, appendix I of that document. In the 2000 FEIS, the National Park Service concluded that, though the bison in Yellowstone National Park are significant to many tribes, they are not a trust resource that would trigger a federal trust responsibility. Thus, the National Park Service does not consider the bison in Yellowstone National Park a trust resource to manage for one or more specific tribes, and as such, trust resources will be affected by the alternatives. However, the National Park Service continues to consult with tribes on bison management issues and to manage the bison in Yellowstone, like the other natural resources in the park, for the benefit of all citizens of the United States.

1.11.9 Geology and Topography

Geology is an important resource topic in Yellowstone National Park and the GYE. Geologic formations were one of the natural wonders that served as the basis for establishing the park. None of the alternatives would have any effect on the surface topography or underlying geology of the park.

1.11.10 Water/Aquatic Resources

Bison in Yellowstone National Park use areas adjacent to surface water, such as creeks, rivers, and ponds. Though there could be impacts to aquatic resources if vaccination activities take place near these resources, the impact would be negligible. Most of the vaccination program would occur in travel corridors or upland grazing areas.

1.11.11 Natural Soundscapes

The NPS is mandated by Director's Order 47 to protect, maintain, or restore the natural soundscape in a condition unimpaired by inappropriate or excessive noise sources. Soundscapes are inherent components of "the scenery and the natural historic objects and the wild life" protected by the NPS Organic Act. It is unlikely that helicopters would be used to transport staff to bison herds for vaccination activities. In addition, the use of projectile devices, such as compressed air-powered rifles, would be short-term, barely audible, and not significantly impact soundscapes in the park.

1.11.12 Wilderness

The Wilderness Act of 1964 established the National Wilderness Preservation System. NPS Management Policies 2006 (NPS 2006) require that wilderness be unimpaired. There are no established wilderness areas within the park. However, portions of the park are proposed for wilderness designation. Vaccination activities would not affect the qualities of these areas proposed as wilderness.

1.11.13 Ecologically Critical Areas, Wild and Scenic Rivers

Yellowstone National Park is an important natural area, but the proposed action would not threaten the associated qualities and resources that make the park unique. The Lewis River and the headwaters of the Snake River are formally designated wild and scenic rivers within the park. Both of these rivers are outside the current distribution of Yellowstone bison.

1.11.14 Caves and Paleontological Resources

No caves or paleontological resources would be impacted by any of the alternatives.

1.11.15 Vegetation

Proposed vaccination activities could potentially affect vegetation and riparian zones. It is possible that unsuccessfully delivered vaccine could potentially remain in vegetation or wetlands. However, there is no data indicating that any residual vaccine on vegetation would affect the growth or survival of the vegetation.

1.11.16 Floodplains and Wetland

Executive Order 11988 (Floodplain Management) and Executive Order 11990 (Protection of Wetlands) require federal agencies to examine the potential long- and short-term effects of critical actions on floodplains and wetlands. It is possible that vaccination activities could occur within or adjacent to 100- or 500-year floodplains or wetlands. However, the vaccination activities will not constitute critical actions as defined in the NPS floodplain management guides.

1.11.17 Prime and Unique Farmlands

In August 1980, the Council on Environmental Quality directed that federal agencies must assess the effects of their actions on farmland soils classified by the USDA Natural Resources Conservation Service as prime or unique. Prime farmland has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops. Unique farmland is land other than prime farmland used for production of specific high-value food and fiber crops. Both categories require that the land is available for farming uses. Lands in Yellowstone National Park are not available for farming and, therefore, do not meet the criteria for prime and unique agricultural lands.

1.11.18 Transportation and Parking

Roads and parking areas in the park are linked to visitor experience, routine park operations, and emergency services. While it is possible that curiosity and traffic congestion could occur during vaccination activities, it is not the intention of the NPS to conduct delivery activities, particularly with compressed air-powered rifles, along park roadsides in a manner that would attract attention from visitors.

1.11.19 Energy Requirements and Conservation Potential

While implementation of the proposed action or alternatives could entail the expenditure of energy through the use of motorized vehicles, this expenditure is not considered a substantial use of national energy resources. There is some potential for conserving energy by travel on horseback and foot to reach bison herds.

1.11.20 Natural or Depletable Resource Requirements and Conservation Potential

None of the alternatives would involve the use of depletable (consumptive) resources.

2. Chapter 2: Alternatives

2.1 Introduction

This chapter describes three alternatives that address the purpose and need for action. These alternatives were developed to explore the possible effects of a range of reasonable actions and strategies that are economically and technically feasible. Alternatives were considered if they met the project purpose and needs as articulated in the program objectives, while protecting the bison population and the other natural resources of the park (Figure 3).

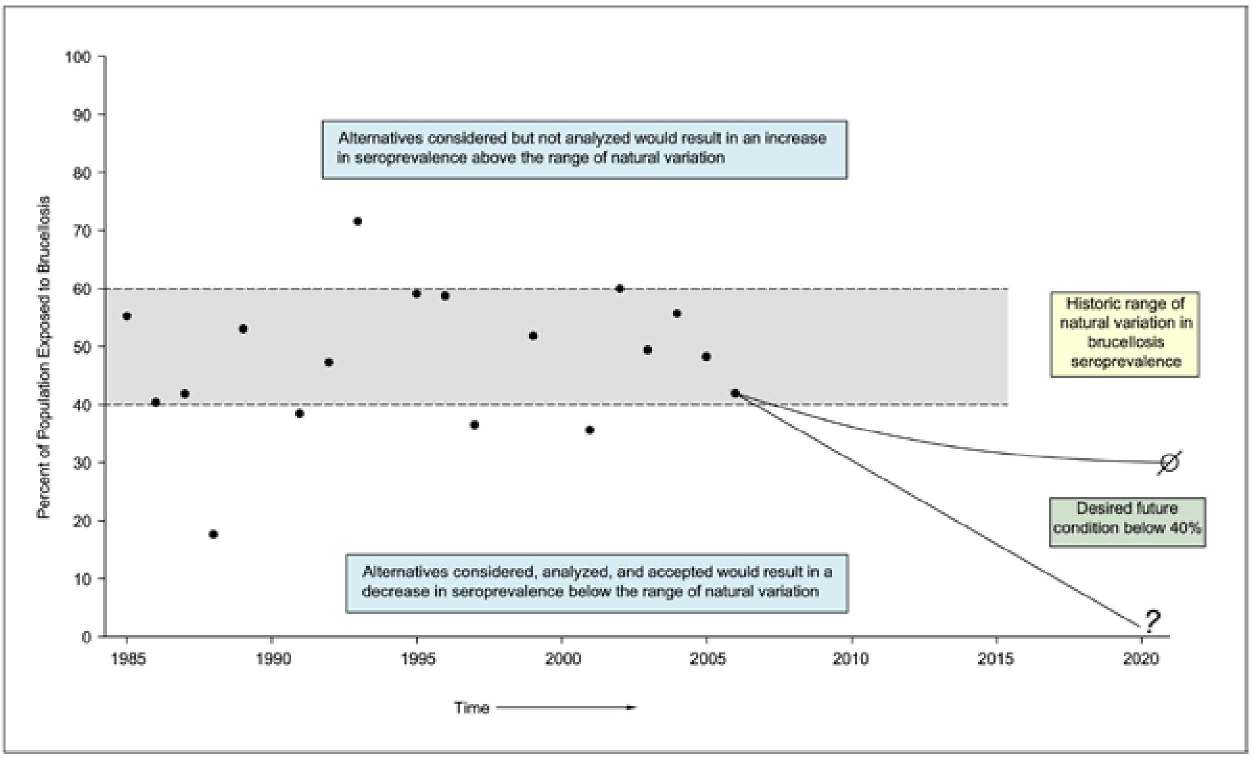

Figure 3. Visual depiction of how alternatives meet the desired future condition of reducing the brucellosis infection rate among Yellowstone bison.

This chapter also includes a description of mitigating measures, alternatives considered but eliminated from further consideration, and a description of the environmentally preferred alternative (40 Code of Federal Regulations [CFR] §1502.14e; 73 Federal Register 61292-61323).

Several criteria are necessary to implement an effective vaccination program:

1. First, an effective vaccination program requires maintaining a large proportion of the population with acquired immunity. This means using the best method possible to stimulate immunity, plus vaccinating a large proportion of the population at the appropriate time of year to stimulate a good immune response.

2. Second, an effective vaccination program requires that all possible routes of re-infection be evaluated, treated, or effectively separated from the vaccinated population. The potential for elk to maintain the disease and re-infect susceptible bison cannot be disregarded.
3. Third, an effective vaccination program needs an effective monitoring strategy to assess progress. Since the detection of infectious individuals cannot be efficiently done via blood sampling, a comprehensive monitoring strategy must be implemented to track a wide variety of infection indicators.

2.2 Actions Common to All Alternatives

2.2.1 Animal Health, Welfare, and the Conservation of Wildlife

There are several animal welfare considerations when implementing a vaccination program for wild, free-ranging bison in the park. These considerations include the humane treatment of bison during handling and vaccination delivery. All of the alternatives considered would include the principles of adequate veterinary oversight or collaboration, detailed record keeping and documentation, and limiting animal discomfort, distress, or pain to short-term effects. While most aspects of these alternatives would be considered management actions that require field studies during implementation, any research components will adhere to the Animal Welfare Act (USDA 2002).

2.2.2 Surveillance Plan (Monitoring the Effects and Effectiveness of Vaccination)

The NPS developed a surveillance plan (Appendix H, White et al. 2008) to obtain timely and useful information for formulating adaptive management adjustments needed to conserve Yellowstone bison, for reducing the risk of brucellosis transmission from bison to cattle, and for reducing the prevalence of brucellosis in the bison population. This long-term monitoring and research program will enable the evaluation of the strength and duration of the immune response in bison following syringe and/or remote (e.g., biobullet) delivery vaccination for brucellosis. It will also enable the documentation of long-term trends in the prevalence of brucellosis in bison, as well as identify how vaccination, other risk management actions (e.g., harvest, culling), and prevailing ecological conditions (e.g. winter-kill, predation) impact these trends. The NPS will work with the IBMP partners (Animal and Plant Health Inspection Service, Forest Service, Montana Department of Livestock, Montana Fish, Wildlife, and Parks) and other scientists and stakeholders to implement surveillance activities conducted under field, captive, and laboratory conditions to collect empirical data for evaluating progress. All alternatives will follow the same strategy for monitoring the effects and effectiveness of vaccination and reducing the seroprevalence of brucellosis in the population. Criteria for determining vaccine safety and effectiveness were previously developed by the Greater Yellowstone Interagency Brucellosis Committee and disclosed in the ROD for the IBMP (USDI and USDA 2000b, Appendix D).

Serostatus refers to the presence or absence of specific antibodies in an effort to diagnose a particular disease from a blood test. The test results can be **seropositive**, indicating the presence of antibodies, or **seronegative**, indicating the absence of antibodies, or inconclusive.

The NPS may mark vaccinated animals via biobullet or paint-ball gun during remote delivery operations and via pit tags implanted subcutaneously under the shoulder blades posterior to the withers during syringe delivery vaccination at capture facilities or field immobilization. This marking will reduce the potential for multiple vaccinations of individuals within a season and contribute to effective surveillance of effects and effectiveness. Ebinger and Cross (2008) suggested that capture and sampling of more than 200 bison during a given year would be necessary to detect significant changes in seroprevalence following vaccination, and that detection would likely take 5-20 years depending on sample sizes and detection method. Thus, as necessary, NPS staff may also capture bison in the Stephens Creek capture facility or dart them with immobilizing drugs to sample their serostatus for brucellosis. The NPS may also request that the State of Montana and Forest Service capture and sample bison at the Duck Creek capture facility outside the western boundary of Yellowstone National Park north of West Yellowstone, Montana per the 2000 ROD for the IBMP and adaptive management actions thereafter (USDI and USDA 2000b, USDI et al. 2008). These captures could occur during hazing operations, with the ultimate release of animals or possible shipment to slaughter of bison testing positive for brucellosis.

> A remote delivery system should have low risk for bison, other animals associated with bison, humans delivering the vaccine, and visitors and employees.
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> An effective remote delivery system would vaccinate sufficient numbers of the population to induce herd level immunity.

2.3 Actions Common to All Remote Vaccination Alternatives

2.3.1 Low Risk and Effective Remote Delivery System

A remote delivery system should have low risk for bison, other animals associated with bison, humans delivering the vaccine, and visitors and employees. A low risk system for bison and non-target species would successfully deliver vaccine to the circulatory (blood) system of target bison without injuring bison (i.e., interfering with body functions), causing changes in the demography (e.g., survival, reproduction) of the bison population, or creating behavioral disturbances (e.g., avoiding use of customary locations or running long distances) to the bison population beyond the range of natural variability. An effective remote delivery system would vaccinate a sufficient number of individuals in the population to induce herd level immunity.

A system that is low risk for humans is one that does not create unnecessary exposure to the vaccine that could cause humans to become infected with brucellosis. Brucellosis vaccines are characterized as modified live vaccines which have a greater risk of infection by human handlers if appropriate precautions are not taken. Stringent handling protocols have been developed to address safety concerns and minimize risk to humans from handling *B. abortus* vaccine while implementing the vaccination program. The delivery system would not create behavioral changes in the bison population that put visitors and employees at risk of direct injury from bison.

2.3.2 Frequency, Location, and Method of Remote Delivery Operations

Vaccination of bison will occur during mid-September through November and, if necessary, March through May at widespread locations in the park (Figure 4). NPS staff will attempt to avoid operations in developed areas of the park such as Mammoth Hot Springs and Tower-Roosevelt during periods when visitors are occupying hotels and restaurants, popular campgrounds, or along popular hiking trails (usually in the summer season). Past documentation of bison movement via monitoring bison fitted with radio-telemetry collars has helped identify potential locations for successful remote delivery of vaccine, including (1) existing major bison travel corridors, (2) topographic relief where natural saddles and draws funnel animals through a narrow landscape feature, and (3) cover for delivery teams (e.g., cabins, trees, and rocks; Clarke et al. 2005).

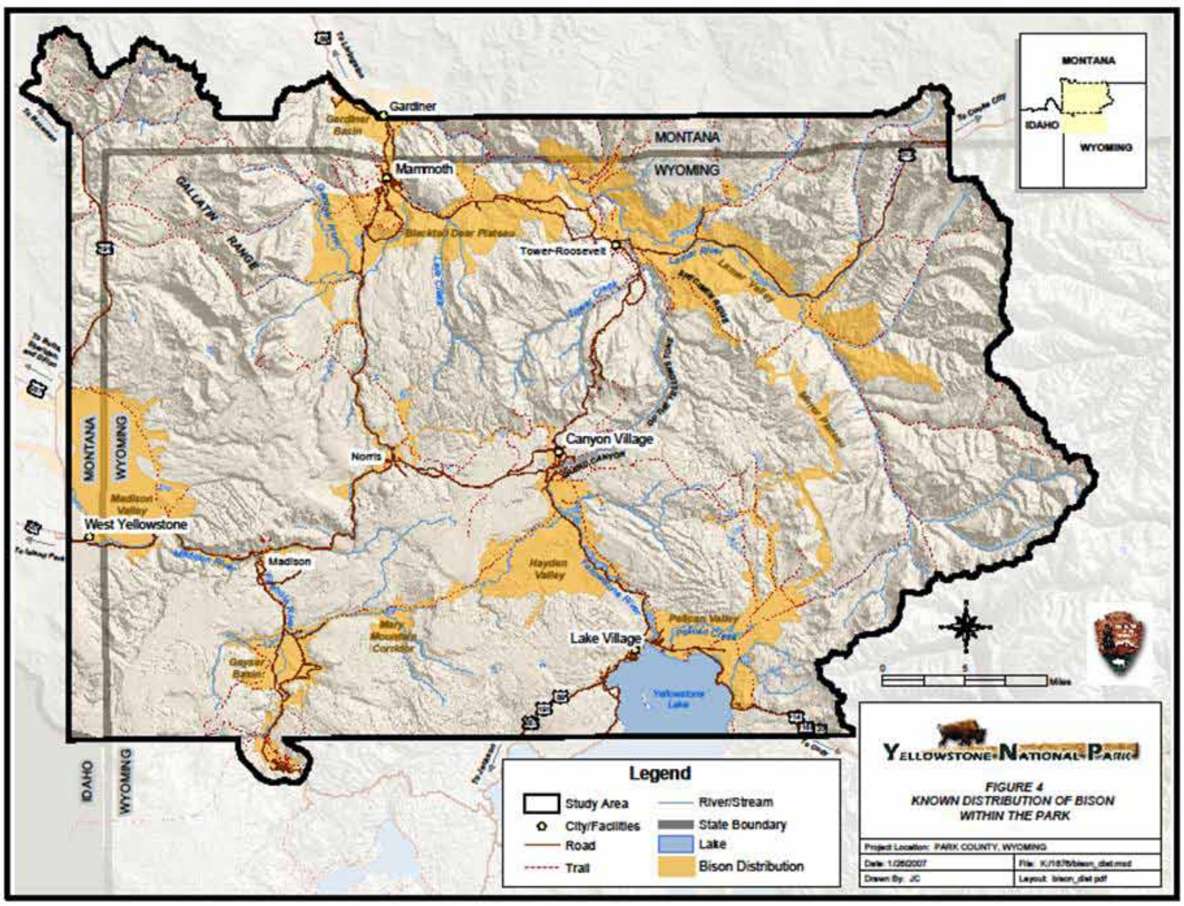

Figure 4. Known distribution of bison within the park.

Two approaches that could be used at vaccination sites are (1) advancing toward bison and vaccinating as the group is moving on the landscape, or (2) finding a location to vaccinate animals as they pass by a delivery team. Bison groups may respond to vaccination by moving away from park staff if several bison struck by the biobullet become agitated. Thus, it will likely take multiple days to vaccinate eligible bison within a given group.

2.3.3 Adaptive Management

The USDI has codified and amended policies and procedures for compliance with NEPA (73 Federal Register 61292-61323). These regulations indicate that bureaus should use adaptive management in circumstances where long-term impacts may be uncertain and future monitoring will be needed to make adjustments in subsequent implementation decisions. A proposed action or alternative may include adaptive management strategies with a monitoring component that allow for adjustment of the action during implementation. The NEPA analysis should identify the range of management options that may be taken as part of an adaptive management approach in response to the results of monitoring and should analyze the effects of such actions. If the adjustments to an action are clearly articulated and pre-specified in the description of the alternative and fully analyzed, then the action may be adjusted during implementation without the need for further analysis (73 Federal Register 61292-61323).

Agencies of the USDI, including the NPS, are encouraged to develop adaptive management programs for resolving difficult management issues (Williams et al. 2007). Adaptive management is a continuous decision-making process whereby the impacts and effectiveness of an action are monitored, and the action is refined in light of new information to enhance progress towards objectives and minimize adverse environmental consequences. In other words, if desired outcomes are not being met, then management actions are reevaluated or altered to achieve them (Figure 5). Adaptive management is most effective in controllable situations where the relationship between monitored conditions and management actions is clear.

Implementing management actions as experiments or case studies rather than predictable outcomes was a novel idea in resource management 20 years ago (Holling 1978, Walters 1986, Walters and Holling 1990). The conceptual approach presented by adaptive management is backed by the principle that learning is valuable (Lancia et al. 1996) and uncertainties exist in resolving many resource management issues (Moir and Block 2001). Adaptive management recognizes this uncertainty in scientific understanding of environmental impacts, but offers a reasonable method for action in the absence of complete information (Thrower 2006). Careful predictions, monitoring of management actions, and adjustments of actions to achieve desired outcomes advances scientific understanding and contributes to the adjustment of policies or operations as part of an iterative learning process.

Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. In fact, ecosystem management requires adaptive management as its method of implementation because complex system components and processes are constantly changing and, as a result, there is substantial uncertainty regarding how systems will respond to disturbances (Ruhl 2005). Adaptive management is not a trial and error process, but rather emphasizes learning while doing. It does not represent an end in itself, but rather a means to more effective decisions and enhanced benefits. The true measure is how well adaptive management helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders (National Research Council 1996, National Research Council, Board on Sustainable Development 1999).

> Adaptive management is a system of management decisions and practices based on clearly identified outcomes, a monitoring strategy to determine if actions are meeting outcomes and, if not, facilitating management changes that ensure effective outcomes are met or reevaluated.
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> It is not a trial and error process, but rather emphasizes learning while doing.

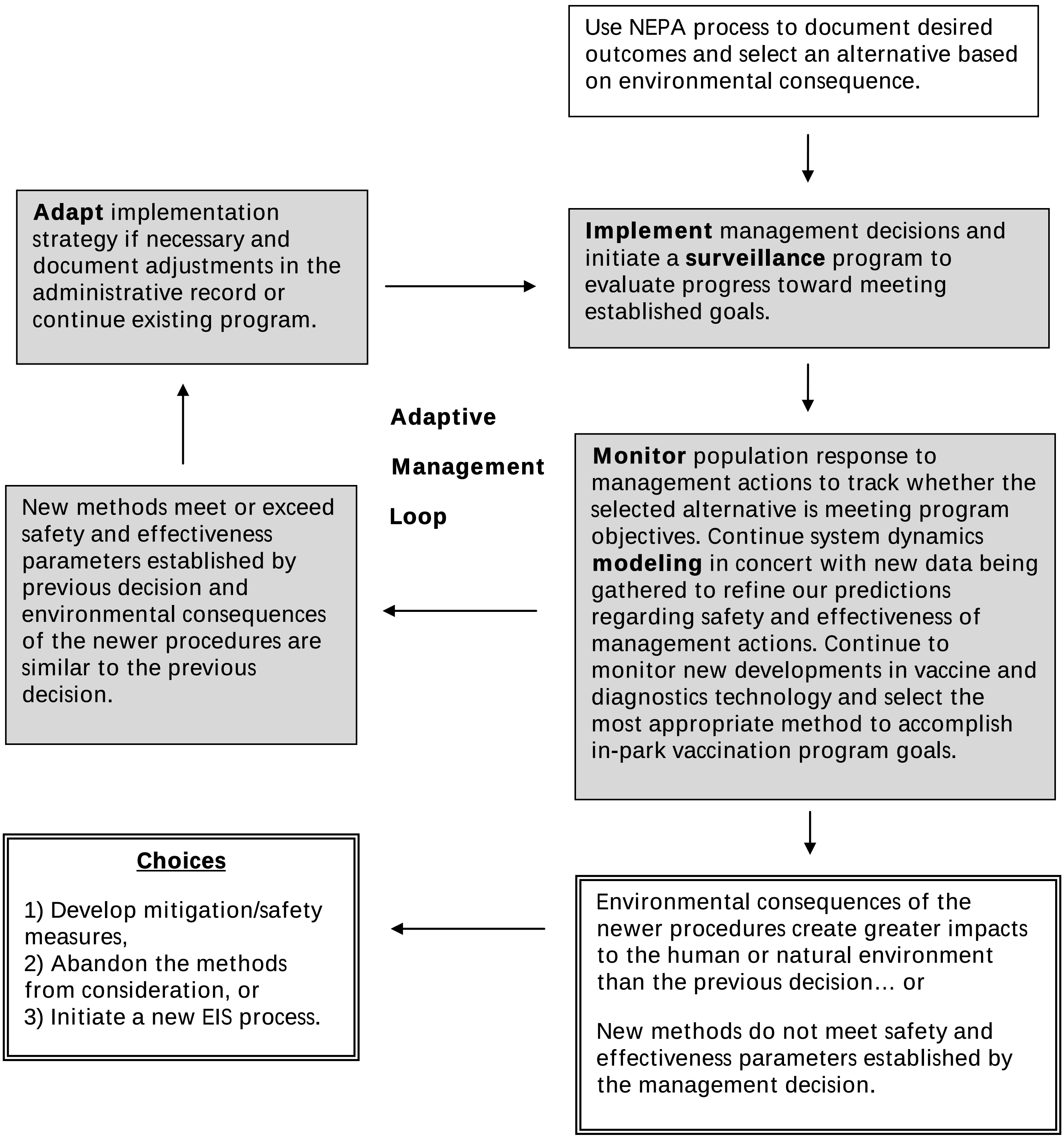

Figure 5. Adaptive Management Process.

The NEPA focuses on ensuring that agencies make an informed choice by requiring collection and consideration of all information regarding the impacts of a proposed action and its alternatives. Adaptive management aligns well with fully informed decision making and NEPA does not provide any barriers to its use if the original NEPA analysis adequately describes adaptive management (Ruhl 2005, Thrower 2006). In fact, NEPA analysis provides the information necessary to develop an adaptive management framework, such as the identification of areas where significant environmental impact is expected, areas of known uncertainty, and possible mitigation measures (Thrower 2006). However, there is no established standard for distinguishing adaptive management adjustments from substantial changes to the original plan that require preparation of a supplemental environmental impact statement. NEPA requires a supplemental environmental impact statement when the subsequent information raises new concerns of sufficient gravity such that another, formal in-depth look at the environmental consequences of the proposed action is necessary (40 CFR § 1502.9(c)(1)). The regulation reads:

"(c) Agencies:

1. Shall prepare supplements to either draft or final environmental impact statements if:
   (i) The agency makes substantial changes in the proposed action that are relevant to environmental concerns; or
   (ii) There are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts.
2. May also prepare supplements when the agency determines that the purposes of the Act will be furthered by doing so.
3. Shall adopt procedures for introducing a supplement into its formal administrative record, if such a record exists.
4. Shall prepare, circulate, and file a supplement to a statement in the same fashion (exclusive of scoping) as a draft and final statement unless alternative procedures are approved by the Council."

The IBMP includes an adaptive management strategy and the details of implementation have been adjusted several times since 2000:

- *2005.*—The IBMP was adjusted in 2005 to include hunting as a management action authorized in the IBMP bison management zones outside Yellowstone National Park (Montana Fish, Wildlife, and Parks and Department of Livestock 2004). This adjustment to the plan authorized the hunting of untested bison by Montana licensed hunters on winter ranges outside the park.
- *2006.*—The IBMP was adjusted in 2006 to define strategic hazing as a management tool to move bison outside the park to lower risk areas also outside the park, to describe increased tolerance for bull bison outside the park, and to clarify that a population size of 3,000 bison was an indicator to guide brucellosis risk management actions, not a target for deliberate population adjustment (USDI et al. 2006).
- *2008.*—Adaptive management adjustments were approved in 2008 to further describe the circumstances for bison occupying habitats outside the park, to establish a precedent for minimizing consignment of bison to slaughter, to re-affirm the commitment to vaccinating bison, to develop a method for sharing decision documents with public constituencies, and to develop a metric for annual monitoring of and reporting on IBMP actions (USDI et al. 2008).

The vaccination program for the Yellowstone bison population will also incorporate adaptive management principles, including a framework of clearly defined elements and a process of management that evaluates if project implementation is meeting the objectives, purpose, and need for action. Though different philosophies exist regarding how adaptive management should be implemented, certain characteristics transcend them, including (1) linkages among key steps such as identifying objectives, implementing monitoring, and adjusting management actions based on what is learned, (2) collaborating with agency and other partners, and (3) communicating with and engaging key stakeholders (U.S. Government Accountability Office 2008).

This NEPA analysis provides a summary of environmental conditions and defines goals for the proposed action. Adaptive management will facilitate reaching these goals by effectively linking surveillance and assessment to objective-driven decision making (Williams et al. 2007). The surveillance program (Appendix H) will provide timely and useful information to federal and state decision-makers from the IBMP partner agencies. This information will be used by managers to determine what, if any, additional actions are needed to conserve bison, reduce the risk of brucellosis transmission from Yellowstone bison to cattle, and reduce the prevalence of brucellosis in the population. System responses to these management actions will then be tracked through continuation of surveillance (Williams et al. 2007). In addition, results from the surveillance program and other research will be used to assess whether new information, vaccines, methods of vaccination delivery, and diagnostics could result in more efficient methods for meeting the purpose and needs of the project (U.S. Animal Health Association 2006).

The boundaries of adaptive management for the proposed action will be limited to changes described within the alternatives of this EIS analysis. Examples of actions related to the vaccination of bison that may be triggered based on information collected during surveillance include:

- Deciding whether to implement remote vaccination based on assessments in controlled environments (e.g., quarantine, captive facilities) of the level of protective immune response following vaccination.
- Deciding whether to continue remote vaccination based on vaccine efficacy, the adequacy of delivery options to obtain the desired reductions in seroprevalence and infection, and the development or validation of improved disease testing to distinguish vaccinates from non-vaccinates.
- Considering alternate vaccines if new lower risk, and more effective, vaccines than SRB51 are developed and tested for bison.
- Considering alternate forms of vaccine delivery that are deemed effective, feasible, and low risk, if surveillance indicates that remote delivery vaccination via biobullets is not inducing a protective immune response in enough eligible bison to eventually achieve our desired outcome (i.e., a 50% decrease in brucellosis seroprevalence).
- Increasing the frequency of vaccination of eligible bison if assessments of the duration of immune protection (i.e., immunological memory) indicate individual bison need to be re-vaccinated to maintain a protective immune response through their lives.
- Discontinuing vaccination in its implemented form if there is no indication of progress (i.e., decrease in seroprevalence and infection in non-reproductive age classes) within

15-20 years, which is the approximate amount of time that may be required to determine how well the goals and objectives are met by the selected alternative (Ebinger and Cross 2008, Appendix I).

- Discontinuing remote delivery vaccination if a minimum level of vaccine delivery (e.g., >50% of eligibles vaccinated) cannot be maintained on an annual basis.

The NPS will document that adaptive management adjustments, both individually and cumulatively, are (1) within the range of management options described for the selected alternative, (2) fully analyzed in the environmental effects section of this NEPA analysis, and (3) do not alter the basic management direction or goals in the original decision (73 Federal Register61292-61323). The NPS will also provide periodic updates on the real impacts of agency actions after the selected alternative is implemented, compared to the expected results. In addition, the NPS will make adaptive management adjustments transparent and accountable to the public, legislatures, and courts by periodically (1) soliciting public comment on adaptive adjustments for consideration by decision-makers, (2) posting surveillance reports on the park's website, (3) holding public information meetings, (4) publishing scientific and other articles and (5) conducting any other necessary analysis

2.4 Alternatives Considered

2.4.1 Alternative A—No Action

No in-park, remote-delivery vaccination operations occur under the no action alternative. The Stephens Creek capture facility would continue to be the only location in the park where bison are vaccinated (USDI and USDA 2000a). The technique used for vaccinating bison is to capture a group of animals by hazing them into a holding pen and subsequently moving these animals through a series of progressively smaller pens to a squeeze chute where technicians draw blood for diagnosing brucellosis exposure status. Bison diagnosed with no antibody response to brucellosis antigen can be re-handled and given a subcutaneous injection of SRB51 vaccine. Currently, only calves and yearlings are vaccinated.

No in-park, remote-delivery vaccination operations occur under the no action alternative. The Stephens Creek capture facility would continue to be the only location in the park where bison are vaccinated.

Under Alternative A, the partner agencies would continue to manage bison abundance and distribution on lands adjacent to Yellowstone National Park, as appropriate, based on evaluations of new conservation easements or land management strategies, reduced brucellosis prevalence in bison, new information or technology that reduces the risk of disease transmission, or different funding available for maintaining separation of bison and cattle. A new more-effective vaccine than SRB51 may be used for vaccination, when available.

The vaccine SRB51 has been studied extensively as a candidate vaccine and found to be low risk for bison (Wallen and Gray 2003). Yellowstone National Park subsequently moved forward with a decision to use this vaccine for purposes of vaccinating bison in the park. While *B. abortus* vaccine SRB51 is licensed for cattle, it has never gained label approval for bison. Thus, the NPS requested and received an experimental use permit from Animal and Plant Health Inspection Service to conduct the vaccination program within the boundaries of Yellowstone

National Park. NPS staff also requested and received letters of permission from the State Veterinarians of Montana and Wyoming to ship an unlicensed biological product (i.e., SRB51) for experimental study and evaluation.

Testing of individual animals requires moving a temporary laboratory facility to the capture pen site, training of individuals that conduct the testing program, and managing contracts to have a veterinarian on-site for validating test results and delivering the vaccine. The following mitigation measures will be implemented as part of Alternative A:

- All vaccination operations would occur at the Stephens Creek capture facility. Vaccination of bison at the Stephens Creek capture pen typically occurs during a short time period (February and March).
- Staff involved in vaccination at Stephens Creek will be limited in number.
- To mitigate health and safety concerns during field operations, the NPS orders vaccine from a supplier when it is imminent that management operations will require vaccination of calves and yearling bison. Consequently, there is little or no storage time at the capture facility.
- Staff clean and disinfect areas where vaccine is mixed and used, and all individuals wear sturdy rubber or plastic gloves when handling the vaccine. Following work with the vaccine, all staff will wash with soap and hot water.
- For the safety of park visitors, an area closure is enforced to keep park visitors from inadvertently encountering operations at Stephens Creek capture facility.
- The NPS estimates that fewer than 500 doses of *B. abortus* Vaccine, SRB51, Live Culture, Code 1261.00 (licensed product for use in cattle prepared by Colorado Serum Company) will be used each year. The product will be formulated at approximately two milliliters per dose and received in small shipments as needed through the winter operations season. To ensure accurate safety records, the NPS will keep records of the number of doses of each type of vaccine received, used, and discarded.
- Stringent bison handling protocols have been developed to address safety concerns and minimize risk to humans implementing the vaccination program.
    - Calm, controlled movement of animals through facility chutes will reduce injuries.
    - Dominant, aggressive animals, such as large bulls, are separated from smaller bison when animals are held at the capture facility. Filling pens with bison of similar age classes reduces some of the injury risk due to confinement in small areas.
    - Monitoring of captive bison is conducted daily to detect animals likely to abort or complete their pregnancy in the capture facility. These animals are separated from the remainder of the group to protect against potential infectious shedding events.
    - All bison held in the capture pen are provided adequate food and water.
- All syringes and needles used for vaccination are sterilized to prevent infection.
- Vaccines are given subcutaneously (under the skin) rather than in muscle tissue to reduce trauma.

- Capture pen operations are limited to one location along the northern boundary of Yellowstone National Park.
- Vaccination at the Stephens Creek capture pen typically occurs in February and March. Few, if any, grizzly bears or wolves are likely to be in this area at this time. No Canada lynx are expected to occupy habitats in this area. The capture pen is further than one mile from known bald eagle nest sites.
- A safety officer is assigned to observe operations and recommend safety guidelines.

2.4.2 Alternative B—Remote-Delivery Vaccination for Young Bison Only

Alternative B would expand the current vaccination program described in Alternative A to include remote delivery of vaccine to bison throughout Yellowstone National Park.

Alternative B would expand the current vaccination program described in Alternative A to include remote delivery of vaccine to young bison throughout Yellowstone National Park. Vaccination with a low risk and effective vaccine delivered by a low risk and effective remote delivery mechanism is the program directed by the 2000 ROD for the IBMP. Expanding the vaccination program would result in a greater proportion of bison being vaccinated against brucellosis and a reduction in disease prevalence.

The concept of remote vaccination of wildlife dates back to the early 1970s when baits containing rabies vaccine were distributed to control this disease in red foxes (Center for Disease Control 2005). Since that time, vaccines have been distributed to many wildlife species in many countries (Appendix C). Oral delivery is the most common method for vaccine delivery to wildlife. However, delivery to non-target animals (e.g., other species or age groups of bison not selected as targets) would be difficult to control and the delivery of an appropriate dose of vaccine to individuals would be difficult to control in a remote wilderness setting (see section in this chapter titled "Vaccination with Remote Delivery Methods that have High Liabilities"). Systematic improvements in delivery mechanisms are expected as more information is available about wildlife ecology and disease epidemiology (Aune et al. 2002). There are no oral *B. abortus* vaccines available for use at this time. Currently, the most feasible method for effective remote delivery of brucellosis vaccine to Yellowstone bison includes the use of a compressed air-powered rifle with an absorbable projectile (i.e., bullet dissolvable in muscle tissue) containing the vaccine known as a biobullet (DeNicola et al. 1996, Cheville et al. 1998, Clause et al. 2002, U.S. Animal Health Association 2006). Methods for encapsulating vaccines into bio-absorbable projectiles are being improved (Christie et al. 2006, Olsen et al. 2006). A biobullet, when delivered to muscle tissue, dispenses the vaccine product within a few hours and the casing is dissolved by muscle tissue fluids in 12 to 24 hours. Minimal tissue damage occurred when biobullets were delivered to large muscle masses of cattle at distances of 6 meters (Morgan et al. 2004).

The two key features that determine success in remotely delivering vaccine to free-ranging wildlife are getting the formulated vaccine into the animals at a safe distance, and controlling the release of the vaccine to maximize the immune system response (Kreeger 1997). Delivering vaccine to bison without capture and handling requires repeatedly approaching them to relatively close distances—a difficult task—and having equipment that can effectively and safely deliver the vaccine. These tasks require patience and experience working in close proximity to wild bison. Biologists at Yellowstone National Park have monitored bison for many years, including annual operations to classify, chemically immobilize, radio-tag, and relocate individuals with telemetry units. Also, park rangers conduct operations in close proximity to bison when hazing or moving groups of bison to new locations on the landscape. However, bison are unpredictable and some groups will inevitably be impossible to approach close enough for the remote delivery system. Gaining experience in recognizing behavioral cues of bison, and adjusting to changing situations, will be essential for maximizing remote delivery efficiency and success.

> The remote delivery system is not designed for high accuracy and long distances like conventional rifles.

In addition, it is important for staff operating the compressed air-powered rifle to become familiar with their individual shooting tendencies. Comparisons of remote delivery equipment showed that careful consideration of the components and distance selected for delivery can affect the probability of effective delivery (Roffe et al. 2002, Wallen et al. 2005). A rifle sighted in at 10 meters will not be as accurate at 20 meters and a shooter will need to either always work to the appropriate distance before delivering the projectile or make appropriate adjustments in the point of aim. The two most feasible target zones on young bison are the thigh (20-30 cm wide) and the shoulder (10-16 cm wide). The skin is 1.5 times thicker on the thigh than on the shoulder, but the hair is much thicker on the shoulder (Quist and Nettles 2003).

In Alternative B, calves (both sexes) and yearling females would remain the focal targets for delivery just as under current implementation (i.e., Alternative A). Vaccination of calves and yearlings could occur during mid-September through November and March through May. This timing would avoid aggressive, rutting bison in large groups during the late-summer months. Also, periods of extremely cold temperatures would be avoided to minimize stress to bison during winter when energy conservation is vital. It is anticipated that remote delivery of vaccine to calves and yearlings will take many months, requiring rotating field teams to systematically travel across the landscape surveying and vaccinating bison. The duration of delivery time is uncertain; it will take a few years to learn bison tolerance for humans in close proximity delivering vaccine. Alternative B would include the possibility of vaccine delivery by two methods. Park personnel could position themselves at a location where bison travel through movement corridors (fixed location), or field technicians would travel through areas supporting bison and vaccinate encountered groups (active approach). Typically, delivery would occur in open valleys (grass and sagebrush habitats), but may also occur in forested areas (lodgepole pine) where bison travel between their dispersed ranges.

> Alternative B would include the possibility of vaccine delivery by two methods. Park personnel could position themselves at a location where bison travel through movement corridors (fixed location), or field technicians would travel through areas supporting bison and vaccinate encountered groups (active approach).

The specific approach strategies for delivering vaccine to bison would involve teams of two to four individuals traveling the landscape by foot, horseback, skis, snowshoes, or in vehicles along roadways and searching for groups of bison. Whether via fixed location or active approach, the team would advance close enough to deliver the biobullet. Distance of approach would be contingent on the behavioral response of bison. Approach to close distance (less than 30 meters) is generally possible during all times of the year. However, not all groups of bison respond similarly to human approach. Approaching individual bison to close distances is more feasible when group sizes are small, typically fewer than 60 animals.

Multiple field teams may be deployed at any given time once field delivery of vaccine is initiated. In some cases, the field team would be able to work around the group of bison while they deliver vaccine to target individuals. If advantageous and suitable sites for a fixed location delivery exist nearby, a portion of the team may relocate to the fixed location while the remaining team members provide low levels of pressure to move bison toward the delivery team waiting at the fixed location.

2.4.3 Alternative C—Remote-Delivery Vaccination for Young Bison and Adult Females

Alternative C would expand the current vaccination program described in Alternative A to include remote delivery of Strain RB51, or a more efficacious and safe vaccine, to bison throughout Yellowstone National Park.

Expanding the vaccination program would result in a greater proportion of bison being vaccinated against brucellosis and a greater chance of reduction in disease prevalence.

This alternative differs by including adult female bison in the remote vaccination program. Thus, more bison would be vaccinated annually under Alternative C than under Alternative B.

Alternative C would expand the current vaccination program described in Alternative A to include remote delivery of vaccine to calves (both sexes) and adult and yearling females throughout Yellowstone National Park. Vaccination with a low risk and effective vaccine delivered by a low risk and effective remote delivery mechanism is the program directed by the 2000 ROD for the IBMP and would be the guiding principle used in implementing this alternative. Expanding the vaccination program would result in a greater proportion of bison being vaccinated against brucellosis and a greater chance of reduction in disease prevalence. The methods for traveling the landscape, locating groups of bison, and approaching groups to deliver vaccine would be the same as described in Alternative B. This alternative differs by including adult female bison in the remote vaccination program. Thus, more bison would be vaccinated annually under Alternative C than under Alternative B. The timing of the vaccination program would avoid the summer breeding season when aggressive, rutting bison congregate in large groups. Approaching bison appears to be most feasible in autumn after the animals break into groups of 25 to 150 animals. After a blanket of snow covers the ground, bison seem to exhibit more tolerance to human approach. Delivery would focus on a period from mid-September through November, but avoid delivery to adult females during the third trimester of pregnancy (mid-January through May) when some research suggests vaccine-induced abortions could occur (Palmer et al. 1996). Periods of extremely cold temperatures would be avoided to minimize stress to bison during difficult time periods during winter when energy conservation is important.

2.5 Mitigation Common to All Action Alternatives (B and C)

The following mitigation measures will be implemented as part of Alternatives B and C:

- Staff conducting remote delivery operations will move about the landscape in a deliberate, controlled manner to provide other wildlife species the opportunity to acknowledge their presence in advance and react by either adjusting their location or choosing to tolerate the human presence in their habitat.
- The remote delivery projectiles are manufactured and encapsulated in a laboratory so field personnel do not handle the live vaccine. The projectiles are small in size and unlikely to be detected on or in the ground by humans if the projectile does not penetrate the targeted bison. These projectile casings dissolve in liquid and the vaccine is rendered inert through exposure to ultraviolet light and warm temperatures.
- The direct and indirect effects resulting from the trauma of remote vaccination could potentially be mitigated by remotely vaccinating bison during autumn when animals are in prime condition, and spring when bison have access to highly nutritious forage. Autumn vaccination would coincide with early gestation making vaccine-induced abortions unlikely. Also, forage of high nutritional value would be beneficial for fighting infections and repairing damaged tissue.
- Knowing the effective range of the biobullet delivery system and consistently delivering vaccine from within this range will limit injury and potential indirect effects.
- Monitoring marked bison groups (e.g., with radio-telemetry collars) that have been remotely vaccinated to determine the effects of vaccination on vital rates (e.g., survival, pregnancy) and the effectiveness of vaccination (e.g., duration of immunity) will help determine the safety and efficacy of the program.
- Using slow and deliberate movements when approaching groups of bison and observing group behavior to determine when to deliver vaccine to additional individuals should help keep bison groups calm while delivery crews are working around them.
- The direct and indirect effects of remote vaccination on bison group tolerance could be mitigated by having two distinct vaccination seasons (i.e., autumn and spring). This strategy would reduce interaction time with each group (as compared to all vaccinations during one time period) and the probability of unacceptable disturbances to bison during field vaccination operations.
- Intensive training and selection of field staff with good understanding of equipment will reduce the probability of poor shot placement.
- Manufacture of vaccine packages in clean, controlled laboratories will ensure vaccine projectiles will not carry non-*Brucella* bacteria during vaccine delivery.
- Stainless steel remote delivery equipment, sealed vaccine projectiles, and radiated clips ensure safest delivery of vaccine for bison to minimize any probability of infection at the injection site.
- All firearms are equipped with trigger guards and safety switches to prevent accidental discharge.
- Equipment is routinely cleaned and inspected to prevent accidental misfire or jamming of the moving parts while a vaccine projectile is chambered.
- Monitoring a group of vaccinated adult females will help determine the probability of vaccine-induced abortions in bison. This data will be used to evaluate the uncertain conclusions provided by Palmer et al. (1996).

- Interpretive staff may be used to explain to visitors witnessing remote delivery operations that approaching closer than the recommended distance of 25 yards is necessary and allowable only for trained staff to accomplish effective vaccination.
- The NPS will notify state wildlife agencies and tribes of forthcoming vaccination efforts through established working groups and communications networks so that hunters can be warned not to consume the meat of a bison killed within 21 days of being vaccinated.
- The NPS may mark vaccinated animals via biobullet or paint-ball gun during remote delivery operations and via pit tags implanted subcutaneously under the shoulder blades posterior to the withers during syringe delivery vaccination at capture facilities or field immobilization to reduce the potential for multiple vaccinations of individuals within a season.
- NPS staff conducting remote delivery vaccination will avoid working near wolf dens or locations where grizzly bears are known to be active. NPS staff will also avoid locations with ungulate carcasses that may be used by grizzly bears or wolves.

2.6 Alternatives Considered But Eliminated From Further Consideration

2.6.1 Low Risk and Effective Remote Delivery System with Vaccine that Results in No Detectable Change

The purpose and need for the action would not be met by a low risk and effective delivery system that uses a vaccine showing no detectable difference between vaccinated bison and bison infected by exposure to *B. abortus* bacteria currently found in the park environment. Use of this type of vaccine would prevent effective monitoring of reduction in brucellosis prevalence because vaccine titers would be indistinguishable from field infection using the currently established trap side diagnostic tests.

Included in this category would be vaccination with Strain 19. Strain 19 was used for calfhood vaccination from the 1960s until 2000 in commercial bison herds. Likewise, during the 1960s Wind Cave National Park and several state parks employed calfhood vaccination with Strain 19—in combination with whole-herd test and slaughter—to control brucellosis in bison herds.

The effectiveness of Strain 19 to impart an immune response against brucellosis exposure is not questioned, and it has been shown to have positive aspects. Studies have found that while 69% of Strain 19 vaccinated pregnant bison aborted their pregnancies, in subsequent pregnancies these individuals exhibited significantly fewer abortions and lower infection rates in comparison with non-vaccinated bison (Davis et al. 1990).

Unfortunately, serological tests for *Brucella* antibodies cannot distinguish between animals that have been exposed or infected with field strain brucellosis and those which have been vaccinated with Strain 19 (Cheville et al. 1998). Strain 19 vaccine was removed from the market by 1996 and replaced with the brucellosis vaccine SRB51 because the newer vaccine does not react to the serological tests used to monitor animal populations for brucellosis. Therefore, this alternative was eliminated from further consideration.

2.6.2 Low Risk and Effective Delivery System that Results in Permanent Changes in Behavior or Demography

> Aerial pursuit would likely disrupt the social behavior of bison… [and could] also result in injuries or even death if animals tripped and fell while running or encountered obstacles to escape. The National Park Service does not intend to conduct extensive capture operations inside the park to handle most individual bison and deliver vaccine because extensive capture operations, as well as confinement to the park, might detract from the wild free-ranging qualities of the bison population and could have a major adverse impact on the distribution of bison.

Aerial delivery of a low risk and effective vaccine using remote delivery equipment was considered and rejected because it would likely result in a detectable change in bison behavior and/or demography (e.g., survival). Aerial delivery was broached by several interested parties in public comments received during the scoping process. However, this technique would involve the use of helicopters to find and vaccinate target individual within bison group. Aerial pursuit would likely disrupt the social behavior of bison by causing them to run and then chasing animals for some distance; possibly into locations they would not normally use. Aerial pursuit could also result in injuries or even death if animals tripped and fell while running or encountered obstacles to escape. The NPS does not intend to conduct extensive capture operations inside the park to handle most individual bison and deliver vaccine because "extensive capture operations, as well as confinement to the park, might detract from the wild free-ranging qualities of the bison population" and "could have a major adverse impact on the distribution of bison" (USDI and USDA 2000a: 415; see also 421-422).

> Herding bison en masse into corrals and vaccinating them by direct contact using syringes was rejected because it would necessitate the repeated capture, temporary confinement, and handling of the whole population. This repeated and direct hands-on contact between humans and bison is in conflict with National Park Service management principles to minimize human intervention to native populations and the processes that sustain them.

Herding bison en masse into corrals and vaccinating them by direct contact using syringes was rejected because it would necessitate the repeated capture, temporary confinement, and handling of the whole population. This repeated and direct hands-on contact between humans and bison is in conflict with NPS management principles to minimize human intervention to native populations and the processes that sustain them. While some park units manage bison by capturing the whole population every year or two, this was evaluated in the 2000 FEIS and found to be impractical at Yellowstone. Other NPS units conduct captures as an action of last resort as it is undesirable from a NPS policy perspective. There could also be unintended consequences to the free-ranging nature of the bison population (i.e., long-term changes in bison behavior). The 2000 ROD for the IBMP and park policy allows this approach for animals that have left the park and are captured at the Stephens Creek facility. However, the approach is contrary to the objectives of remote delivery to free-ranging animals. This type of strategy was analyzed and not selected in the 2000 FEIS that directed the IBMP.

2.6.3 Vaccination with Killed Vaccines

Current and past vaccines against brucellosis such as Strain 19 and SRB51 have primarily been live bacterial vaccines, since live bacteria produce a more efficient long-term immunity against the disease. However, the stability of live vaccines is relatively low, which limits available delivery methods. Live vaccines require refrigeration to maintain viability and pose infection risks to humans working with the vaccines in the field.

Among currently feasible killed vaccines, DNA vaccines are promising. The basic principle of DNA vaccination is that plasmid DNA (pDNA) containing the gene of interest is delivered to tissue of the host. This stimulates an immune response in the host animal, including activation and proliferation of T-cells that kill intracellular pathogens, and production of antibodies that attack extracellular pathogens including many bacteria.

DNA vaccines have many advantages over earlier forms of live vaccines (Alarcon et al. 1999). Unlike attenuated live vaccines, DNA vaccines have few known side effects and cannot (1) revert to virulence through mutation because they are not living organisms, nor (2) shed from carriers. DNA vaccines induce broad protective immune responses, activating both humoral and cell mediated components of the immune system. DNA vaccines are inexpensive, easy to produce and, because they are stable, do not require refrigeration. Therefore, they are much easier to maintain and distribute than conventional vaccines. The goal of developing a low risk and effective DNA or other type of killed vaccine for brucellosis in wildlife seems attainable, but the technology is still being developed. Also, any candidate vaccine must undergo research in large mammal studies before it would be available and considered for use on Yellowstone bison. Thus, the killed vaccine alternative was eliminated from further consideration because the technology is not ready for implementation. The NPS may reconsider this alternative when scientists develop a killed vaccine that induces protective levels of cell-mediated and mucosal immunity in bison, as well as an effective delivery mechanism.

2.6.4 Vaccination with Remote Delivery Methods that have High Liabilities

Oral or ballistic delivery methods hold the most promise for distributing vaccine to Yellowstone bison. The advantages of oral vaccination include ease of distribution and relatively low cost, while disadvantages include lack of control over which animals are vaccinated and the doses received by individuals. Since oral transmission of brucellosis is considered the primary route of pathogenesis, some have suggested that vaccination may be more effective if the vaccine is delivered by the natural route of exposure (Nicoletti and Milward 1983, Cheville et al. 1998). There are no oral *B. abortus* vaccines available for consideration at this time.

Aerosols and baits are thought to be effective methods for imparting an appropriate immunity, but have many limitations. Difficulties inherent in aerosols include control of delivery to non-target animals (e.g., other species or age groups of bison not selected as targets), and control of appropriate vaccine dosing to individuals in a remote wilderness setting. Nasal delivery by administering a vaccine in a mist has merit, but is currently unsafe due to the risk of human exposure to live vaccines. Vaccine that is sprayed over an area, but not delivered directly to bison, and eventually settles on the landscape also has unknown risks. Oral baits also have an uncertain effectiveness because of (1) the uncontrolled nature of dosage each animal receives, and (2) safety issues regarding exposure to non-target animals and humans. Regulatory restrictions exist that do not allow distribution of vaccine in an uncontrolled manner. Development of new technologies that produce killed vaccines may make these two delivery methods more feasible at a later date. Dart delivery of vaccine presents some liability risks that are not associated with the biobullet. Such risks include darts with non-degradable needles that the field crew could not find after delivery being left behind in the ecosystem. Darts that are not found would be classified as a bio-hazard, and those with live vaccine remaining would be an additional safety risk if discovered by uninformed or irresponsible humans. Biodegradable and needless darts hold some promise for consideration and will be considered as adaptive management adjustments to field methods.

> Oral and aerosol remote delivery mechanisms were considered, but rejected, due to the uncertainty regarding their effectiveness to deliver a proper dosage to a target population. In addition, the use of darts containing vaccine was considered but determined not feasible because of the liability of lost darts left about the landscape.

Oral and aerosol remote delivery mechanisms were considered, but rejected, due to the uncertainty regarding their effectiveness to deliver a consistent recommended dosage to a target population. In addition, the use of darts containing live *B. abortus* vaccine was considered but determined not feasible because of the liability of lost darts left about the landscape. Therefore, this alternative was eliminated from further consideration because it did not meet the objective of delivering a vaccine using a low risk or effective delivery system.

2.7 Environmentally Preferred Alternative

NPS policy (NPS 2006) requires that an EIS identify the environmentally preferred alternative as defined by the Council of Environmental Quality (Section 101[b], 42 USC 4331). These regulations and guidelines describe the environmentally preferred alternative as the one which best meets six criteria or objectives defined by the Council of Environmental Quality:

- Fulfill the responsibilities of each generation as trustee of the environment for succeeding generations.
- Ensure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings.
- Attain the widest range of beneficial uses of the environment without degradation, risk of health or safety, or other undesirable and unintended consequences.
- Preserve important historic, cultural, and natural aspects of our national heritage and maintain, wherever possible, an environment that supports diversity and variety of individual choice.
- Achieve a balance between population and resource use that will permit high standards of living and a wide sharing of life's amenities.
- Enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

NPS staff qualitatively assessed how well each alternative met these criteria and concluded that Alternative C was the environmentally preferred alternative based on the rationale in the following paragraphs.

Alternative C provides the greatest intent to achieve a balance between population and resource use. This alternative best meets the objective of reducing brucellosis prevalence in the Yellowstone bison population, while indirectly reducing the tension between the National Park Service and State of Montana staff regarding management philosophies and other related issues. A reduced probability of individual bison being infected and occupying habitat outside the park provides greater balance for preserving the bison population and easing the concerns of Montana citizens regarding standards of living for agricultural industry workers.

All of the alternatives would meet the intent of fulfilling the responsibilities of each generation as trustee of the environment. Each alternative addresses the concerns of NPS management to protect the Yellowstone bison from the effects of infection by the non-native bacteria, *B. abortus*, which was introduced to the local environment nearly 100 years ago by domestic livestock. All of the alternatives would meet the objective to assure safe, healthful, productive, and aesthetically and culturally pleasing surroundings for all Americans. No habitat modifications are proposed under any of the alternatives. Alternative A was the lowest risk action analyzed because it involves the least amount of live bacteria vaccine distributed to Yellowstone bison. The mitigation measures that would be used to implement Alternatives B and C minimize the risk of distributing *B. abortus* vaccine in the environment. Both of these alternatives propose the use of a fully encapsulated vaccine that degrades rapidly if delivery inadvertently fails to connect with targeted bison. Alternative C would best meet the purpose of attaining the widest range of beneficial uses of the environment without degradation, risk of health and safety, or other undesirable and unintended consequences. Alternative C would result in the most bison avoiding infection with brucellosis.

All of the alternatives would preserve equally the important historic, cultural, and natural aspects of the national heritage, and maintain an environment that supports diversity and variety of individual choice. Vaccination of bison in Yellowstone National Park would not diminish the opportunities of visitors to choose their recreational activities within the park environment. In addition, all historic, cultural, and natural aspects of resources in Yellowstone National Park would remain as they are today. Alternative C provides the greatest intent to achieve a balance between population and resource use. This alternative best meets the objective of reducing brucellosis prevalence in the Yellowstone bison population, while indirectly reducing the tension between the NPS and State of Montana staff regarding management philosophies and other related issues. Resource managers are concerned about the potential for Yellowstone bison to spread brucellosis to Montana livestock. A reduced probability of individual bison being infected and occupying habitat outside the park provides greater balance for preserving the bison population and easing the concerns of Montana citizens regarding standards of living for agricultural industry workers.

All of the alternatives would equally enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources. The Yellowstone bison population generates an enormous amount of public interest by visitors that come to the park to observe this icon of the western Great Plains. A population with a reduced probability of infection by non-native organisms would add value to this already important population of bison. None of the alternatives proposed in this study would damage the biological or physical environment of Yellowstone National Park or other portions of the GYE. Alternative C, however, would best protect, preserve, and enhance this historic and culturally valuable natural resource.

2.8 Future Surveys and Regulatory Compliance Necessary to Implement the Project

This Environmental Impact Statement represents the most comprehensive type of analysis described by the National Environmental Policy Act (NEPA) and, as such, analyzes all the potential impacts for all the actions proposed. Consequently, NEPA compliance will be considered complete for all actions proposed in that alternative (unless otherwise stated in the document), as outlined in the Record of Decision that will follow.

Pursuant to NEPA, all federal actions that have the potential to affect the environment must undergo some type of analysis through an established process before a decision is made. This EIS represents the most comprehensive type of analysis described by NEPA and, as such, analyzes all the potential impacts for all the actions proposed. Consequently, NEPA compliance will be considered complete for all actions proposed in that alternative that is selected (unless otherwise stated in the document), as outlined in the ROD that will follow.

During specific design and implementation phases for the selected alternative, the park's NEPA interdisciplinary team and Bison Ecology and Management Program will continue to review and monitor all implementation components proposed in this EIS to ensure that all regulatory compliance is completed. The following is a list of additional tasks that will need to be completed to implement the project once an alternative has been selected, documented in a Record of Decision, and the preliminary design has been initiated:

- Application to and receipt of a permit from Animal and Plant Health Inspection Service, Center for Veterinary Biologics, to package vaccine and deliver vaccine in a manner that is different than that described by the label on the vaccine product.
- Develop a cooperative agreement with industries that manufacture remote delivery products and those that manufacture vaccine to design methods for packaging and procurement of products that can be used in a remote vaccination program.
- Conduct or review the findings of experiments in controlled environments (e.g., quarantine, captive facilities) to determine the strength and duration of the protective immune responses in bison following syringe delivery vaccination with SRB51 or new vaccines.
- Conduct or review the findings of experiments in controlled environments to determine the strength and duration of protective immune responses in bison following remote delivery (e.g., biobullet) vaccination with SRB51 or new vaccines.
- Conduct field trials to determine the strength and duration of protective immune responses in bison following remote delivery vaccination with SRB51 or new vaccines.

2.9 Comparison of Alternatives

In accordance with the requirements of NEPA (42 USC § 4321 et seq.), Table 3 summarizes the chief features of each alternative in comparative fashion. Table 4 compares alternative with the project objectives. Table 5 summarizes the direct and indirect impacts of each alternative on park resources and values. Figure 3 is also included to visually depict how the alternatives will meet the desired outcome of the remote vaccination program.

Table 3. Summary of alternatives for remote vaccination of free-ranging bison in Yellowstone National Park

	ALTERNATIVE A (No Action)	ALTERNATIVE B (Vaccination with Low Risk and Effective Vaccine/Low Risk and Effective Remote Delivery System)	ALTERNATIVE C (Vaccination with a Low Risk and Effective Vaccine / Low Risk and Effective Remote Delivery System)
Vaccinate young of both sexes	X	X	X
Vaccinate adult females	–	–	X
IBMP vaccine requirement	Safe (i.e., low risk)	Low risk and effective	Low risk and effective
Stephens Creek facility used for vaccination	X	X	X
Alternative includes remote delivery method	–	X	X
Vaccinate during spring	X	X	X
Vaccinate during fall	–	X	X
Notes	The NPS is implementing a program to vaccinate seronegative calf and yearling bison of both genders released after capture and testing occurs at the Stephens Creek facility. Vaccination is by syringe using SRB51.	This alternative would expand the current vaccination program to include remote vaccination of bison (same target class as Alternative A) throughout the park. The locations within the park where remote vaccination would occur would be widespread across bison habitat, avoiding areas of high human activity.	This alternative would expand the current vaccination program to include remote vaccination of bison throughout the park and expand the target class to include adult females.

Table 4. Comparison of alternatives and objectives

Objectives	Alternatives		
	A - No Action	**B – Remote vaccinate young bison**	**C - Remote vaccinate young bison and adult females**
Decrease the probability of individual bison shedding field strain *B. abortus*.	This alternative would decrease the probability of vaccinated bison shedding *B. abortus* in the short term. However, this action is focused on young bison and does not address the issue of long-term immunity that most experts agree is not attainable using an attenuated live vaccine. It is difficult to achieve lifetime immunity to intracellular pathogens through vaccination.	While a greater proportion of young bison would receive vaccine, the uncertainty about the duration of immunity would remain if this alternative is selected. The probability of vaccinated bison shedding *B. abortus* would decrease over the short term.	The largest proportion of the Yellowstone bison population would be vaccinated if this alternative is selected. The duration of immunity would be monitored and data would be accumulated to address this uncertainty.
Lower the brucellosis infection rate of Yellowstone bison.	Over the long term brucellosis infection is expected to decrease. The decrease in population infection rate is expected to be negligible during a 20-year implementation period but minor in effect after 30 years of implementation.	Over the long term, brucellosis infection is expected to decrease. The decrease in population infection rate is expected to be minor over a 20-year period, but moderate in effect after 30 years of implementation.	The analysis model used to describe the environmental consequences to bison suggests that vaccination of adults could lead to a more rapid decrease in disease prevalence than vaccination of young and non-pregnant bison alone. The decrease in population infection rate is expected to be moderate to major within 20 years.
Test, monitor, and adjust for a safe, effective, low risk, in-park remote delivery system for vaccination-eligible bison within the park.	This objective would not be met under the No Action alternative as a remote delivery system will not be implemented.	Testing the program would be possible under Alternative B, but minimally informative, (given that only young bison will be vaccinated and duration of immunity is considered less than life-long). Thus, the effectiveness of reducing risk of transmission is expected to be negligible to minimum.	Alternative C would be the best program to test with the expectation that it would be the most effective strategy and, thus, the most new information to gain through monitoring. Especially given that the duration of immunity challenge is more appropriately addressed in Alternative C.

Table 5. Comparison of environmental impacts by alternative

RESOURCE	IMPACT	ALTERNATIVE A	ALTERNATIVE B	ALTERNATIVE C
Individual Bison				
Injury	type context duration intensity area	adverse indirect short-term minor local	adverse indirect short-term minor local	adverse indirect short-term minor local
Tissue trauma	type context duration intensity area	adverse direct short-term negligible local	adverse direct/indirect short-term negligible to minor local	adverse direct/indirect short-term negligible to minor local
Duration of immunity	type context duration intensity area	beneficial indirect short-term (uncertain) minor local	beneficial indirect short-term (uncertain) minor local	beneficial indirect long-term (uncertain) major local
Vaccine-induced abortion	type context duration intensity area	no impacts	no impacts	adverse direct short-term negligible to minor
Bison Population				
Seroprevalence reduction	type context duration intensity area	beneficial direct short-term/long-term minor to moderate regional	beneficial direct short-term/long-term moderate regional	beneficial direct short-term/long-term major regional
Calving rate	type context duration intensity area	beneficial indirect short-term minor regional	beneficial indirect long-term minor regional	beneficial indirect long-term minor regional
Population growth	type context duration intensity area	beneficial indirect short-term negligible regional	beneficial indirect long-term minor regional	beneficial indirect long-term minor regional
Reduction in amount of *B. abortus* shed on landscape	type context duration intensity area	beneficial direct short-term minor regional	beneficial direct short-term moderate regional	beneficial direct short-term major regional

Table 5. cont.

RESOURCE	IMPACT	ALTERNATIVE A	ALTERNATIVE B	ALTERNATIVE C
Bison Population continued				
Behavior - reaction to remote delivery methods	type context duration intensity area	not applicable	adverse indirect short-term minor regional	adverse indirect short-term minor regional
Herd immunity	type context duration intensity area	beneficial indirect long-term minor regional	beneficial indirect long-term minor regional	beneficial indirect long-term major regional
IBMP Management Goals				
Management options	type context duration intensity area	beneficial direct long-term minor to moderate regional	beneficial direct long-term minor to moderate regional	beneficial direct long-term minor to moderate regional
Transmission	type context duration intensity area	beneficial indirect short-term minor local	beneficial indirect long-term moderate local	beneficial indirect long-term major local
Other Wildlife				
Behavior	type context duration intensity area	adverse direct short-term negligible local	adverse direct short-term minor local	adverse direct short-term minor local
Vaccine exposure	type context duration intensity area	adverse indirect short-term minor local	adverse indirect short-term minor local	adverse indirect short-term minor local
Transmission	type context duration intensity area	beneficial indirect long-term negligible to minor local	beneficial indirect long-term minor regional	beneficial indirect long-term minor regional

Table 5. cont.

RESOURCE	IMPACT	ALTERNATIVE A	ALTERNATIVE B	ALTERNATIVE C
Ethnographic Resources				
	type context duration intensity area	adverse direct/indirect short-term/long-term minor to moderate regional	adverse direct/indirect short-term/long-term moderate regional	beneficial direct/indirect short-term/long-term moderate regional
Health and Human Safety				
Park employees	type context duration intensity area	adverse direct short-term minor local	adverse direct/indirect short-term minor local	adverse direct/indirect short-term minor local
Visitors	type context duration intensity area	no impacts	no impacts	no impacts
Visitor Use and Experience				
	type context duration intensity area	adverse indirect short-term negligible local	adverse/beneficial indirect short-term minor local	adverse/beneficial indirect short-term minor local
Park Operations				
Communication with agencies, constituents, and political leaders	type context duration intensity area	adverse direct short-term negligible to minor local	adverse/beneficial direct/indirect short-term/long-term minor to moderate regional	adverse/beneficial direct/indirect short-term/long-term moderate to major regional

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3. Chapter 3: Affected Environment

This chapter describes the physical, biological, and human environment in Yellowstone National Park that could be affected by implementation of any of the alternatives described in Chapter 2. The resource descriptions in this chapter serve as the baseline from which to compare the potential effects of management actions with respect to a vaccination program.

3.1 General Project Setting

The analysis area is part of the GYE, which is the largest and most nearly intact ecosystem in the contiguous United States (Greater Yellowstone Coordinating Committee 1991, Keiter and Boyce 1991). Yellowstone National Park encompasses 2.2 million acres. The portion of the GYE specifically subject to analysis includes approximately 220,000 acres in the central and northern portions of Yellowstone National Park that were historically occupied by bison (Figure 2).

The landscape of the analysis area is characterized by high-elevation shrub steppe and grasslands with well-defined riparian corridors surrounded by moderately steep slopes of the local mountain ranges and plateaus. The Gallatin and Absaroka mountain ranges dominate the northwestern and eastern boundaries of the park. The Washburn Range, Central Plateau, Solfatara Plateau, and Mirror Plateau encompass the intervening high points within the analysis area. The Pelican Creek watershed is located at the southeast portion of the analysis area and drains directly into Yellowstone Lake. The Gibbon and Firehole rivers (both tributaries of the Madison River) are key features of the south and west portion of the analysis area. Several other small watersheds occur in the area of analysis, including Duck and Cougar creeks in the Madison Valley and Sedge Creek east of Mary Bay on Yellowstone Lake. Soda Butte and Slough creeks drain into the Lamar River, which forms the Lamar Valley (6,700 feet in elevation) in the northeastern area of the park. The moderately hilly topography on top of Mount Everts and the Blacktail Deer Plateau is bounded on the north by the Black Canyon of the Yellowstone River and on the south by Folsom and Prospect Peaks (Barmore 2003). The Yellowstone River flows through a wide valley northwest of Gardiner, Montana and is generally less than 5,500 feet in elevation.

3.2 Yellowstone Bison Population

Bison are most often seen grazing in open meadows and along river valleys (Meagher 1973). Like most ungulates of western North America, bison vacate their higher elevation summer ranges as winter snow pack accumulates. Yellowstone National Park thermal areas are important winter feeding grounds due to the easy accessibility of plants growing on the warmer soil. The heat from warm ground and thermal features also reduces the amount of energy bison must expend to keep warm in winter. Sedges and grasses are the preferred diet of Yellowstone bison (Meagher 1973).

The Yellowstone bison population has substantially increased in abundance since the initiation of restoration efforts in 1902 (Meagher 1973, Gates et al. 2005). During the implementation of the IBMP, the population has increased from approximately 2,400 bison in 2000 to more than 5,000 bison in 2005 (Clarke et al. 2005, Fuller et al. 2007*a*). To reduce the risk of brucellosis transmission from bison to cattle more than 900 bison were consigned to slaughter during winter 2005-06, and more than 1,400 bison were consigned to slaughter during winter 2007-08.

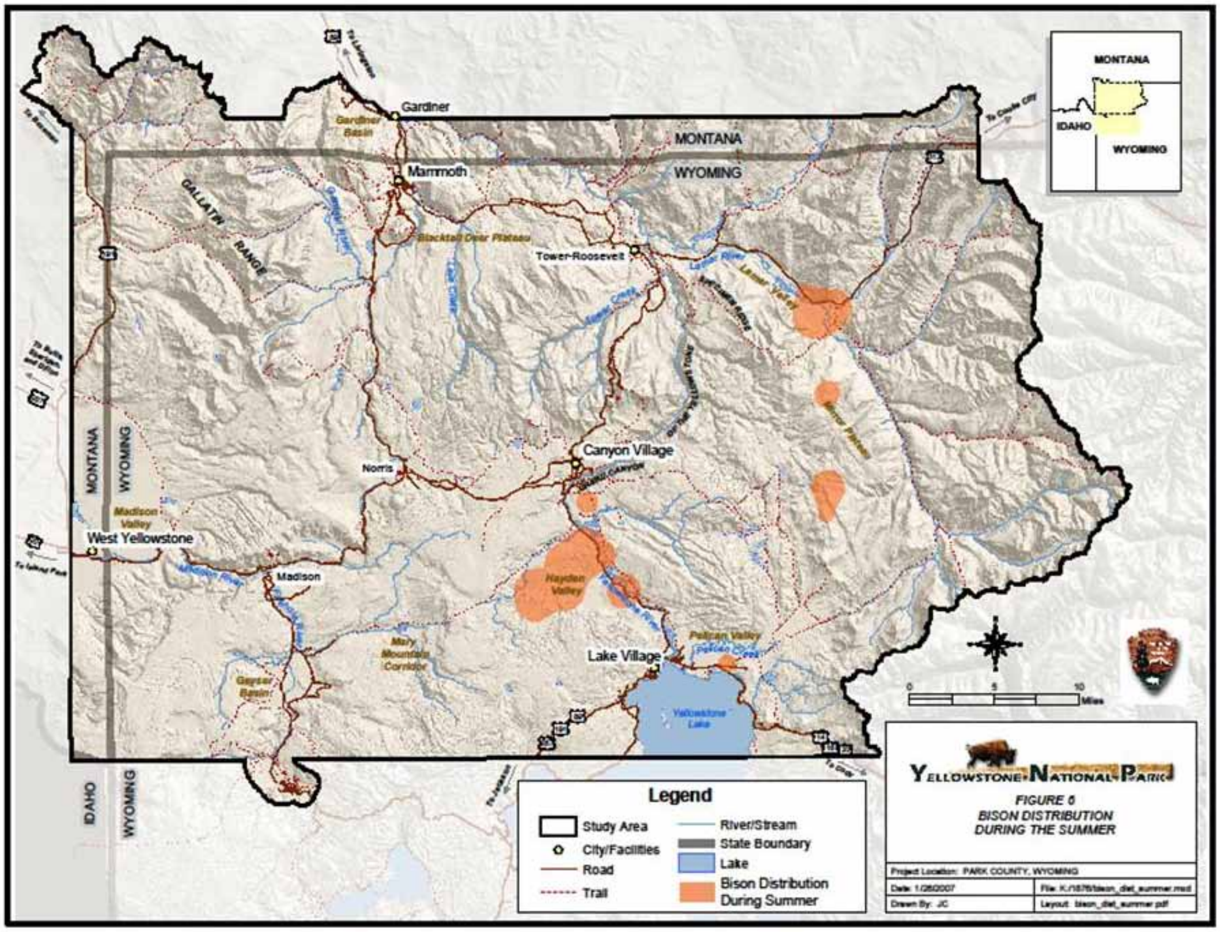

Figure 6. Bison distribution during summer.

Bison are social animals with a maternal hierarchal herd structure (Meagher 1973, Cheville et al. 1998, USDI and USDA 2000a). Maximum herd cohesion occurs during summer when bison concentrate in the Hayden Valley, Mirror Plateau, and Lamar Valley for the breeding season (Figure 6). Winter concentrations are more dispersed in six geographically separated locations that contain narrow corridors for movement between winter range areas (Table 6, Figure 7).

The gregarious nature of bison results in continuous opportunities for groups to encounter other groups. The dynamics of group cohesiveness are little understood, but their social order requires that they manage many relationships through their lives. Probably the most complex of these relationships occurs during the courtship period (Lott 2002). Bulls of all ages spar to determine their individual dominance, with the winners earning the right to reproduce with willing females.

To reduce the risk of brucellosis transmission from bison to cattle more than 900 bison were consigned to slaughter during winter 2005–06, and more than 1,400 bison were consigned to slaughter during winter 2007–08.

Table 6. Bison ranges throughout Yellowstone National Park	
Ranges	**Period of Use**
Lamar Valley	Year-round, with higher elevations used only in summer and autumn
Gardiner Basin; Horse Butte	Limited use in autumn; peak use in late winter and spring; decreasing use in late spring and early summer
Pelican Valley	Peak use after breeding through mid-winter; decreasing use in spring
Hayden Valley	Year-round, but with smaller numbers in late winter
Geyser Basins	Increasing use in autumn, with maximum use in winter and spring
Madison Valley	Moderate use in autumn; decreasing use in early winter; increasing use in late winter and peak use in spring

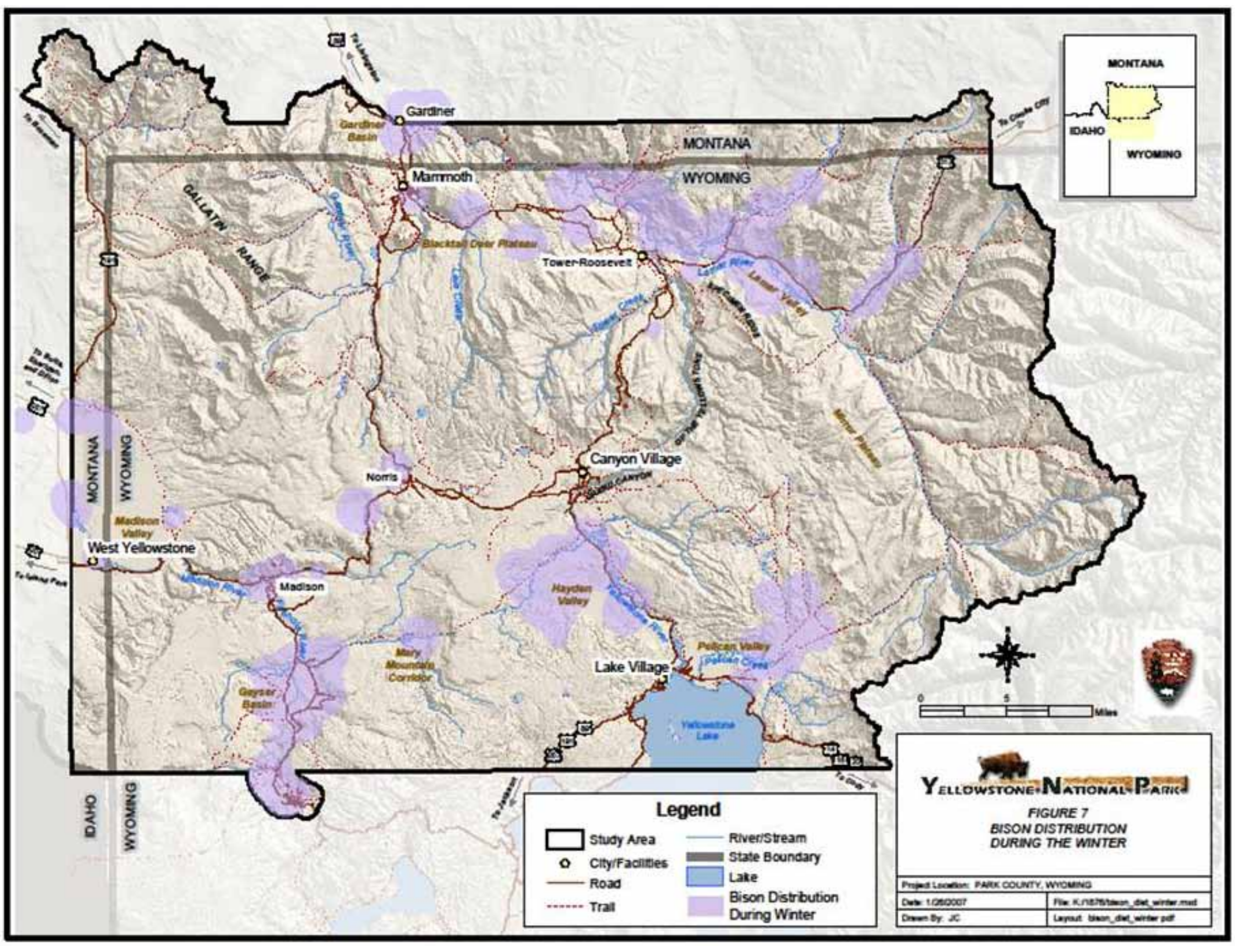

Figure 7. Bison distribution during winter.

Not only does competition play a role in the social dynamics of the group, but there is evidence of attraction, rejection, and cooperation both within and between the sexes. These interactions appear to drive group sizes and the individual makeup of these groups. Following courtship, the mature males separate and spend the rest of the year alone or in small groups. The rest of the population disperses into groups dominated by adult females. Group size shrinks through the autumn and into winter, reaching its lowest level of the year during March and April (Figure 8).

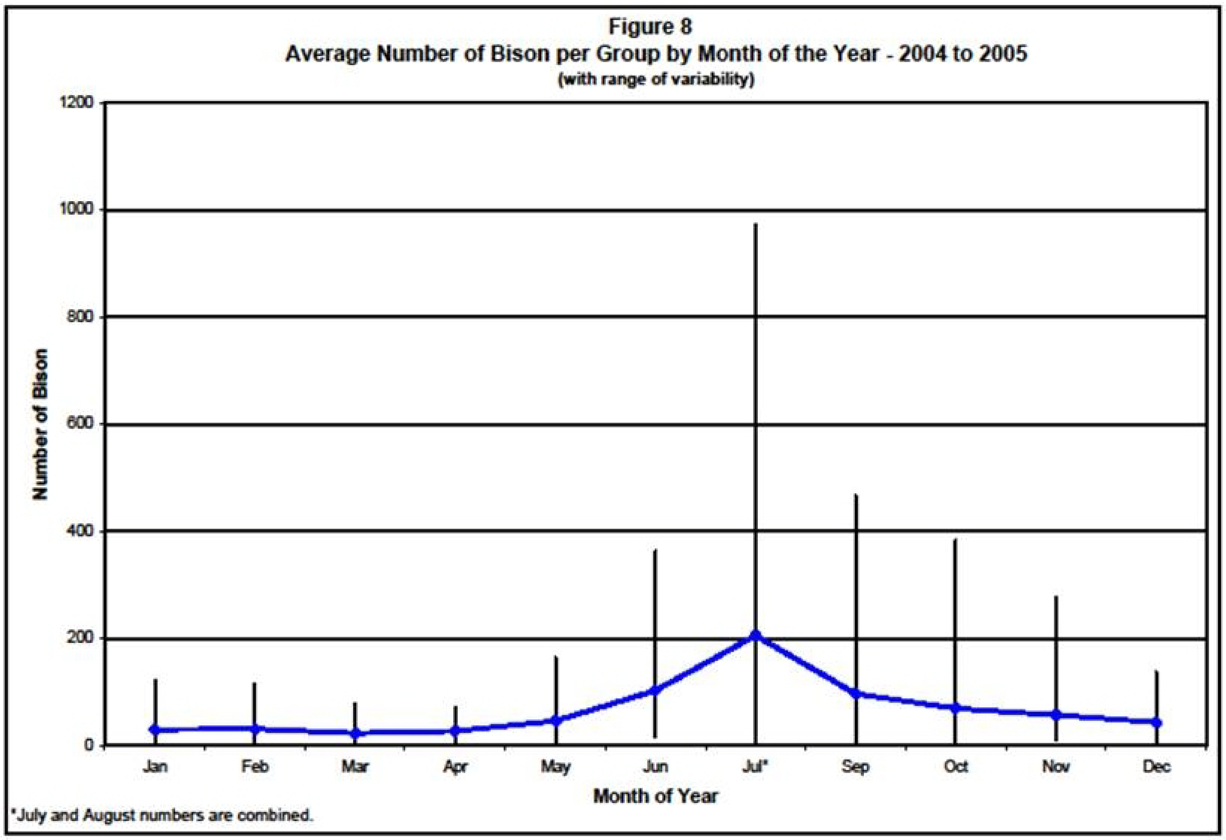

Figure 8. Average number of bison per group by month of year.

3.3 *Brucella abortus* in Wildlife of the Greater Yellowstone Ecosystem

Ungulates are highly susceptible to brucellosis, with experimental studies suggesting that bison, elk, and cattle are equally susceptible to infection (Davis et al. 1990, Cheville et al. 1998). Yellowstone bison have tested positive for infection since brucellosis was first detected by J. R. Mohler in 1917 (Tunnicliff and Marsh 1935). Today, both the Yellowstone and Jackson bison populations are chronically infected with *B. abortus* (Cheville et al. 1998), with 40-60% of Yellowstone bison testing positive for exposure to *B. abortus* during 1985 to 2008.

Elk on winter feed grounds in the GYE have an average serological (blood serum) prevalence of 30% (Galey et al. 2005). Elk that winter away from feed grounds on less densely populated wintering ranges in the GYE have historically had a prevalence of exposure less than 3% (Clause et al. 2002, Galey et al. 2005). However, seroprevalence rates in some of these elk herds (Gooseberry, Cody, Clarks Fork) appear to have increased to more than 7-10% since about 2002. This increase is possibly due to elk-to-elk disease transmission from elk aborting on lower elevation public or private winter ranges with high numbers of aggregated elk (Hamlin and Cunningham 2008, Cross et al. 2009).

Four cases of brucellosis in wild moose (*Alces alces*) were reported between 1937 and 1985 (Cheville et al. 1998). Available information indicates that pronghorn, mule deer, bighorn sheep (*Ovis canadensis*), and mountain goats (*Oreamnos americanus*) rarely test positive for brucellosis (Cheville et al. 1998), though infection is possible (Kreeger et al. 2004).

Some wild carnivores in areas that contain infected bison and elk have been exposed to *B. abortus.* Ninety percent of bovine fetuses experimentally placed in various habitats within the southern GYE from February to March were scavenged and disappeared within four days (Cook 1999). Aune et al. (2007) observed similar results in experiments conducted in the northern GYE. Predation and scavenging by carnivores likely decontaminates the local environment of infectious *B. abortus* (Cheville et al. 1998). Brucellosis has been detected in black bears and grizzly bears in the GYE, though the extent of infection in the population is unknown (Cheville et al. 1998). Studies have documented *B. abortus* titers in blood samples collected from carnivores but these species are considered dead-end hosts and unlikely transmission vectors (Tessaro 1986, Cheville et al. 1998, Olsen et al. 2004). Approximately 100 wolves in Yellowstone National Park have been sampled for the presence of *Brucella* antibodies since 1995, but none of the tests resulted in positive detections.

> Bears are unlikely to play a major role in the persistence of brucellosis in the Greater Yellowstone Ecosystem (Cheville et al. 1998). Approximately 100 wolves in Yellowstone National Park have been sampled for the presence of *Brucella* antibodies since 1995, but none of the tests resulted in positive detections.

3.4 *Brucella abortus* in Cattle of the Greater Yellowstone Ecosystem

In February 2008, after 74 years of an eradication program, the entire United States cattle population was declared brucellosis-free (USDA 2008). However, this achievement was short-lived because several cases of brucellosis exposure in cattle were detected in Montana and Wyoming during 2007 and 2008. Transmission in each case was attributed to free-ranging elk, not bison. As a result, Montana lost its class-free brucellosis status in 2008 and livestock producers have incurred increased testing costs and marketing complications to verify that livestock are brucellosis-free.

Though recent brucellosis transmissions to cattle were attributed to elk, the risk of brucellosis transmission from bison to cattle is tangible, especially without management to maintain separation (Flagg 1983, Davis et al. 1990, Cheville et al. 1998). Kilpatrick et al. (2009) indicated that the risk of transmission of brucellosis from bison to

> Several cases of brucellosis exposure in cattle were detected in Montana and Wyoming during 2007 and 2008. Transmission in each case was attributed to free-ranging elk, not bison. As a result, Montana lost its class-free brucellosis status in 2008.

cattle would increase with increasing bison numbers and severe snow fall or thawing and freezing events. These authors also indicated that as the area bison occupy outside Yellowstone National Park in the winter encompasses new area and additional cattle grazing (as they indicated was presently occurring), the risk of transmission will increase. This risk could be reduced by vaccination of bison and cattle.

3.5 Other Wildlife

Yellowstone National Park has a diverse fauna, with 11 species of amphibians, ten species of reptiles, 337 species of birds, 81 species of mammals (including seven species of native ungulates), and 19 species of fishes. Bison, the largest ungulate in the park, play an important role in Yellowstone National Park, from modifying plant communities to providing food for predators and scavengers. Seven other ungulate species use the park seasonally or year-round, including elk, pronghorn, mule deer, white-tailed deer, moose, bighorn sheep, and mountain goats. Most ungulates migrate to low-elevation winter ranges in and surrounding the park. Migratory routes and winter destinations are driven by climate, geology, elevation, and vegetation diversity.

Large carnivores in the park include grizzly bears, black bears (*Ursus americanus*), mountain lions (*Puma concolor*), and wolves. Coyotes (*Canis latrans*) are also abundant in the park. Predation on bison by grizzly bears is rare, but some bears prey more on bison than others (Varley and Gunther 2002, Wyman 2002). Elk are the primary prey for wolves in the park because they are more abundant and easier to kill than bison (Smith et al. 2004). However, wolves are known to focus on bison calves during winter (Jaffe 2001, Smith et al. 2000).

Many species of mammals, birds, and insects that scavenge bison carcasses may be affected by a vaccination program for bison. Besides the large predators already discussed, eagles (two species), ravens, magpies, and many other species of smaller perching birds along with coyotes, red foxes (*Vulpes vulpes*), badgers (*Taxidea taxus*), and numerous carnivorous insects are likely to scavenge on bison carcasses.

3.6 Threatened and Sensitive Species

Section 7(a)(2) of the Endangered Species Act of 1973, as amended (16 U.S.C. § 1531 et seq.) directs all federal agencies to use their existing authorities to conserve threatened and endangered species and, in consultation with the Secretary (Secretary of the Interior and/or Secretary of Commerce), ensure their actions do not jeopardize listed species or adversely modify proposed or designated critical habitat. Each year the USFWS provides a park-wide list of endangered, threatened, and candidate species protected by the Endangered Species Act. This list is intended as a general reference for planning purposes to meet the intent of the initial consultation to determine species likely to be found in the project planning area. As a part of the consultation process, a Biological Assessment was completed (Jones et al. 2006). The following paragraphs summarize the best available scientific information for federally listed species, recently delisted species, and species of special concern in Yellowstone National Park. The arctic grayling (*Thymallus arcticus*) is a candidate species expected to occur within the park. However, arctic grayling currently exist in the park only as adfluvial introduced populations (Varley and Schullery 1998).

3.6.1 Canada lynx

Canada lynx (*Lynx canadensis*) (Lynx) is a close relative of the bobcat (*Lynx rufus*). Lynx require cold boreal and montane conifer forests with dense understories that receive heavy snowfall and that support snowshoe hares, the lynx's principal prey (65 FR 16052). The Distinct Population Segment of lynx in the contiguous United States was listed as threatened under the Endangered Species Act in 2000 because existing regulatory mechanisms in Forest Service Land and Resource Management Plans were inadequate to protect lynx or lynx habitat (65 FR 16052). Critical habitat for lynx was designated in Yellowstone National Park and surrounding lands in southwestern Montana and northwestern Wyoming (Unit 5; 74 FR 8616).

> The presence and distribution of lynx in the park was documented during 2001–2004, when several individuals were detected in the vicinity of Yellowstone Lake and the Central Plateau.

Lynx in the contiguous United States are considered part of a larger metapopulation whose core is located in the northern boreal forest of Canada. Lynx disperse from Canada into the United States and help bolster populations in the U.S. Northern Rocky Mountains and the North Cascades Range (McKelvey et al. 2000). Three lynx populations occur from western Montana to Washington, though survey data are not currently sufficient to estimate population sizes or trends (65 FR 16058).

Historical information suggests that lynx were present, but uncommon, in Yellowstone National Park during 1880 to 1980 (Murphy et al. 2004). The presence and distribution of lynx in the park was documented during 2001-2004, when several individuals were detected in the vicinity of Yellowstone Lake and the Central Plateau (Murphy et al. 2004, 2006). No lynx were detected in other areas of the park, though reliable detections of lynx continue to occur in the national forests that surround the park. Evidence suggests that lynx successfully reproduce in the GYE, though production of kittens is limited.

In accordance with the Canada Lynx Conservation and Assessment Strategy (Ruediger et al. 2000), park staff mapped suitable lynx habitat—typically late successional or mature forests dominated by mesic subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmanni), and lodgepole pine (Pinus contorta var. latifolia)—and lynx habitat currently in an unsuitable condition (successional forests 1–20 years post disturbance). Twenty Lynx Analysis Units ranging from 33,000–155,000 acres were identified. These 20 units were primarily associated with andesitic and sedimentary-based soils common in the northern and eastern portions of the park (Despain 1990). No Lynx Analysis Units were identified in the central and west-central portion of the park where dry lodgepole pine stands predominate at successional climax. Lynx Analysis Units typically occurred in the backcountry of Yellowstone National Park, though seven were transected by major park roads.

Managers use the standards and guidelines provided in the Canada Lynx Conservation and Assessment Strategy to gauge the effects of park projects on lynx. Under the strategy, projects that occur outside Lynx Analysis Units have no effects on lynx. Projects inside Lynx Analysis Units may affect lynx, but not adversely, if the location occurs (1) outside of lynx habitat, (2) in lynx habitat that is currently unsuitable for lynx foraging, or (3) in lynx foraging habitat but ample suitable habitat is otherwise available. We anticipate that few vaccination operations would occur in lynx habitat.

3.6.2 Gray wolf

> On March 6, 2009, the Secretary of the Interior affirmed the decision by the U.S. Fish and Wildlife Service to remove gray wolves from the list of threatened and endangered species in the Northern Rocky Mountain states of Idaho and Montana, while wolves in Wyoming would remain an endangered species.

Gray wolves were eliminated by humans from the northern Rocky Mountains by the 1930s. In 1978, the USFWS published a rule (43 FR 9607) listing them as endangered at the species level throughout the conterminous 48 States and Mexico (except for Minnesota where the gray wolf was reclassified to threatened). On November 22, 1994 the USFWS designated unoccupied portions of Idaho, Montana, and Wyoming as two nonessential experimental population areas for the gray wolf under section 10(j) of the Endangered Species Act (59 FR 60252). This designation enabled the reintroduction of 31 wolves from southwestern Canada into Yellowstone National Park during 1995 and 1996 (Bangs and Fritts 1996). This restored population rapidly increased in abundance and distribution and achieved its distributional, numerical, and temporal recovery goals for the GYE by the end of 2002 (USFWS et al. 2003).

There were approximately 171 wolves residing in 11 packs in Yellowstone National Park during 2007, but additional significant growth is unlikely because suitable habitat is saturated with resident wolf packs and conflict among packs appears to be limiting population density (Smith 2005). Thus, maintaining wolf populations above recovery levels in the GYE segment of the northern Rocky Mountains area will likely depend on wolf packs living outside the National Park/Wilderness portions of Wyoming (71 FR 43413).

As a result, the USFWS required that Idaho, Montana, and Wyoming develop wolf management plans to demonstrate that other adequate regulatory mechanisms exist should the Endangered Species Act protections be removed. The USFWS proposed delisting wolves in the northern Rocky Mountains and transferring management to state wildlife agencies pursuant to approved wolf management plans (72 FR 36939). The final rule removing wolves in Idaho, Montana, and Wyoming from the List of Endangered and Threatened Wildlife and Plants was published on February 27, 2008 (73 FR 10514). However, a preliminary injunction restoring Endangered Species Act protections for the northern Rocky Mountain gray wolf was granted on July 18, 2008 due to (1) a lack of evidence of genetic exchange between subpopulations, and (2) approval by the USFWS of Wyoming’s wolf management plan despite the State’s failure to commit to managing for 15 breeding pairs and the plan’s malleable trophy game area. On March 6, 2009, the Secretary of the Interior affirmed the decision by the USFWS to remove gray wolves from the list of threatened and endangered species in the Northern Rocky Mountain states of Idaho and Montana, while wolves in Wyoming would remain an endangered species. Several plaintiffs have asked the U.S. District Court of Montana to invalidate the delisting of wolves in Idaho and Montana, but a final determination on the case has not been reached.

3.6.3 Grizzly bear

Grizzly bears were listed as a threatened species in the lower 48 states during 1975 (70 FR 69858) because the GYE population had been reduced to 229-312 bears due to low adult female survival (Knight and Eberhardt 1985). The GYE grizzly bear population is discrete from other grizzly populations, has markedly different genetic characteristics, and exists in a unique ecological setting where bears use terrestrial mammals as their primary source of nutrition

(Mattson 1997, Miller and Waits 2003, 70 FR 69865). Intensive management has resulted in this population increasing at a rate of 4-7% per year since the early 1990s and more than 500 bears now persist in the GYE (Swartz et al. 2006). The range and distribution of grizzly bears have expanded and since 2000 counts of unduplicated females with cubs born that year have increased to more than double the Recovery Plan target of 15 (Haroldson 2006). Eighteen of 18 Bear Management Units in the GYE were occupied by female grizzly bears with cubs-of-the-year during 2000-2005 (Podruzny 2006). Thus, there are sufficient numbers and distribution of reproductive individuals to provide a high likelihood that the grizzly bear will continue to exist and be well distributed throughout its range and additional suitable habitat for the foreseeable future (70 FR 69881).

As a result, the USFWS established a distinct population segment of the grizzly bear for the GYE and concurrently removed it from the Federal List of Endangered and Threatened Wildlife on April 30, 2007 (72 FR 14866). As part of this proposal, grizzly bear habitat security in the Primary Conservation Area, which includes Yellowstone National Park, is primarily achieved by managing motorized access which (1) minimizes human interaction and reduces potential grizzly bear mortality risk, (2) minimizes displacement from important habitat, (3) minimizes habituation to humans, and (4) provides habitat where energetic requirements can be met with limited disturbance from humans (70 FR 69867). To prevent habitat fragmentation and degradation, the number and levels of secure habitat, road densities, developed sites, and livestock allotments will not be allowed to deviate from 1998 baseline measures (70 FR 69882). On September 21, 2009, the U.S. District Court of Montana vacated the final rule designating the Yellowstone distinct population segment and removing the Yellowstone grizzly bear distinct population segment from the list of threatened species.

3.6.4 Bald eagle

Due to a population decrease caused by dichloro-diphenyl-trichloroethane (DDT) and other factors, bald eagles (*Haliaeetus leucocephalus*) were listed as an endangered species under the Endangered Species Act in 1978 for 43 of the conterminous states, and threatened in the states of Michigan, Minnesota, Wisconsin, Oregon, and Washington (43 FR 6233). In subsequent years, habitat protection, management actions, and reductions in levels of persistent organochlorine pesticides (such as DDT) resulted in significant increases in the breeding population of bald eagles throughout the lower 48 States. In response, the USFWS reclassified the bald eagle from endangered to threatened in 1995 for the 43 contiguous states (60 FR 36000). Populations of bald eagles continued to increase and current data indicate the bald eagle has recovered in the lower 48 states, with an estimated minimum of 7,066 breeding pairs today compared to 487 active nests in 1963 (71 FR 8239).

Numbers of nesting and fledgling bald eagles in Yellowstone National Park also increased incrementally during 1987-2007 (McEneaney 2006, 2007). Resident and migrating bald eagles are now found throughout the park, with nesting sites located primarily along the margins of lakes and shorelines of larger rivers. The bald eagle management plan for the GYE achieved the goals set for establishing a stable bald eagle population in the park, with a total of 26 eaglets fledged from 34 active nests during 2005 and 2007 (McEneaney 2006, 2007). This is the highest number of fledged eaglets recorded to date in Yellowstone National Park and the increasing population trend indicates habitat is not presently limiting the growth of the population. Thus, the population has likely not yet reached carrying capacity and may continue to increase in the near future. The USFWS removed the bald eagle from the List of Endangered and Threatened

Wildlife on August 8, 2007 (72 FR 37346). The current ESA designation is delisted/recovered with a recovery plan calling for monitoring of their status every 5 years from 2008 to 2028.

3.6.5 American peregrine falcon

The American peregrine falcon (*Falco peregrinus anatum*) was removed from the List of Endangered and Threatened Wildlife and Plants on August 25, 1999. The removal was prompted by its recovery following restrictions on organochlorine pesticides in the United States and Canada, and implementation of various management actions including the release of approximately 6,000 captive-reared falcons (64 FR 46541). The USFWS has implemented a post-delisting monitoring plan pursuant to Section 4(g)(1) of the Endangered Species Act that requires monitoring peregrine falcons five times at three-year intervals beginning in 2003 and ending in 2015. Monitoring estimates from 2003 indicate territory occupancy, nest success, and productivity were above target values set in the monitoring plan and that the peregrine falcon population is secure and vital (71 FR 60563).

Peregrine falcons reside in Yellowstone National Park from April through October, nesting on large cliffs. The numbers of nesting pairs and fledglings in Yellowstone National Park steadily increased from zero in 1983, to 31 pairs and 50 fledglings in 2006, to 32 pairs and 47 fledglings in 2007 (McEneaney 2006, 2007).

3.6.6 Wolverine

The wolverine (*Gulo gulo*) is a wide-ranging mustelid that naturally exists at low densities throughout much of northern and western North America (Banci 1994). Wolverines are highly adapted to extreme cold and life in environments that have snow on the ground all or most of the year (Aubry et al. 2007). In the conterminous United States, these habitats are highly mountainous and occur at elevations above 8,000 feet (Copeland et al. 2007). Mature females reproduce infrequently, typically giving birth at three-year intervals (Persson et al. 2006). They excavate snow and have young in tunnels; they are sensitive to human disturbance during the period from February to May when young are born and travel little (Magoun and Copeland 1998). Overexploitation through hunting and trapping, as well as predator poisoning programs, likely caused wolverine populations to contract since the early 1900s along the southern portion of their historical range in North America (Banci 1994). However, recent surveys indicate wolverines are widely distributed in remote, montane regions of Idaho, Montana, Washington, and parts of Wyoming (68 FR 60113).

Wolverines have been detected in the GYE, including along the eastern, northern, and southern portions of the park (Inman et al. 2007, Beauvais and Johnson 2004, Copeland et al. 2006). Wolverines have protected status in Washington, Oregon, California, Colorado, Idaho, and Wyoming (Banci 1994). In Montana, wolverines are classified as furbearers and trapper harvests are managed through a quota system that limits the number of individuals that can be taken. Trapping may be detrimental to the wolverine population in and near Yellowstone National Park because survival is substantially lower in trapped populations (Krebs et al. 2004).

In response to a second petition to list the wolverine as a threatened or endangered species, the USFWS ruled in October 2003 that listing in the contiguous United States was not warranted based on the best available scientific and commercial information (68 FR 60112). A reevaluation of this finding, mandated by a federal court, was completed in March 2008 and upheld the 2003 ruling (73 FR 12929). This finding was subsequently litigated and a settlement was entered into on June 10, 2009, whereby the Service agreed to reconsider and submit a new finding to the FR by December 1, 2010.

3.6.7 Pronghorn

Pronghorn in Yellowstone National Park were identified as a Native Species of Special Concern by Yellowstone National Park because they have considerable biological and historical significance. This population was one of only a few not exterminated or decimated by the early 20th century and, as a result, was the source for re-establishing or supplementing populations throughout much of its range (Lee et al. 1994). These pronghorn express much of the genetic variation that was formerly widespread in the species, but no longer present elsewhere (Reat et al. 1999). Also, this population sustains one of only a few long-distance migrations by pronghorn that persist in the GYE (White et al. 2007).

There are serious concerns about the viability of Yellowstone pronghorn because low abundance (fewer than 300) and apparent isolation have increased their susceptibility to random, naturally occurring catastrophes (National Research Council 2002). The population exhibits irruptive dynamics with periods of relative stability for 10-15 years, punctuated by relatively rapid, dramatic fluctuations in numbers (Keating 2002). These dynamics have been accompanied by rapid changes in mating behaviors and migration tendencies (White et al. 2007). The Yellowstone pronghorn migration was effectively truncated by up to 80 km outside the park due to development and habitat fragmentation (Caslick 1998, Scott 2004). Several summering areas were abandoned after culls and translocations during the 1940s-1960s (Scott and Geisser 1996, Keating 2002). Along with these challenges, Yellowstone pronghorn share a 30-km^2 winter range with thousands of other ungulates, including elk, bison, mule deer, and bighorn sheep that compete for forage. This large concentration of ungulates has reduced the density and productivity of big sagebrush (*Artemisia tridentata*), which was the staple winter food of pronghorn during 1930-1990 (Singer and Norland 1994, Singer and Renkin 1995).

3.6.8 Trumpeter swan

Trumpeter swans (*Cygnus buccinator*) were nearly extinct by 1900, but a small group of birds survived by remaining year-round in the vast wilderness of the GYE. This remnant population enabled the restoration of the species and today there are approximately 30,000 trumpeter swans in North America (USFWS 1998).

Yellowstone National Park supports resident, non-migratory trumpeter swans through the year, as well as regional migrants from the GYE and longer-distance migrants from Canada and elsewhere during winter. The estimated abundance of resident trumpeter swans in Yellowstone National Park decreased from a high of 59 individuals in 1968 to 10 individuals in 2007. There was some evidence that this decrease in abundance became more dramatic after supplemental feeding of swans outside the park (e.g., Centennial Valley, Montana) was terminated in the winter of 1992-1993 (Proffitt et al. 2009*a*). There was little evidence of density dependent effects (i.e., numbers of migrants) on the resident population growth rates, but rates were lower following severe winters, wetter springs, and warmer summers (Proffitt et al. 2009*a*). During 1987-2007, the proportion of adults breeding annually ranged from 0.27 to 0.67 ($\bar{x}$ = 0.52), an average of 6.1 pairs nested in Yellowstone National Park, and an average of 2.7 cygnets survived until September (Proffitt et al. 2009*b*). This overall low productivity of trumpeter swans suggests that the decrease in resident swan abundance will likely continue unless swans dispersing from other areas immigrate to Yellowstone National Park. Thus, trumpeter swan presence may be limited to ephemeral residents and wintering aggregations of migrants from outside the park (Proffitt et al. 2009*a*, *b*).

3.6.9 American white pelican

The American white pelican (*Pelecanus erythrorhynchos*) was identified by Yellowstone National Park as a Native Species of Special Concern because (1) nesting attempts decreased from more than 400 during the mid-1990s to 128 during 1999, and (2) Yellowstone National Park has the only current nesting colony of white pelicans in the national park system (McEneaney 2002). In 2007, a total of 427 pelicans nested and fledged 362 young, suggesting the subpopulation has recovered somewhat from the substantial decrease during the mid- to late-1990s.

Pelican control in the 1920s, followed by human disturbances in the 1940s and 1950s, kept the population at low levels. Since that time, pelican numbers have increased, but still fluctuate greatly from year to year, both in the number of nesting attempts and fledged juveniles. Flooding occasionally takes its toll on production, along with disturbance from humans and predators (McEneaney 2002).

The shallow-spawning Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*) is the main food for white pelicans in Yellowstone National Park. However, there are serious threats to this subspecies that could affect white pelicans, including interbreeding with introduced rainbow trout (*Oncorhynchus mykiss*), the illegal introduction of lake trout (*Salvelinus namaycush*) which prey upon cutthroat trout, and several outbreaks of whirling disease in major spawning tributaries. The recent drought in the GYE has made several spawning tributaries run dry in late summer, preventing cutthroat fry from migrating to Yellowstone Lake and thus making them easy prey for predators such as gulls and pelicans. These threats have significantly reduced cutthroat populations in Yellowstone Lake and adjacent parts of the Yellowstone River.

3.7 Ethnographic Resources

The Great Plains and the northern Rocky Mountains of western Montana and Wyoming were part of the natural range of bison from prehistoric times. This region is also the homeland of various native peoples who hunted these ranging herds. Archeological evidence places the earliest human occupation in Yellowstone National Park at 11,000 years ago, though some tribes have said they occupied the lands much longer. No fewer than 10 tribes dwelled in the GYE during both historic and prehistoric times. Tribes whose traditional territory included portions of the Yellowstone Plateau include the Crow, Eastern Shoshone, Salish and Kootenai, Shoshone-Bannock, Blackfeet (see footnote 4 of Table 7), Nez Perce, Northern Arapaho, and Northern Cheyenne tribes. The GYE also contained important hunting grounds for many tribes. As late as the

> No less than 10 tribes dwelled in the Greater Yellowstone Ecosystem during both historic and prehistoric times. Tribes whose traditional territory included portions of the Yellowstone Plateau include the Crow, Eastern Shoshone, Salish and Kootenai, Shoshone-Bannock, Blackfeet, Nez Perce, Northern Arapaho, and Northern Cheyenne tribes.
>
> A few tribes currently claim hunting rights within Yellowstone National Park, including the Shoshone-Bannock who roamed the western portion, the Crow who traversed the east, and some First Nations of Canada (Blackfoot, Blood, Piegan, and Assiniboine) who also hunted in the region.

l880s, a band of Shoshone known as the Sheepeaters occupied portions of what is now Yellowstone National Park. A few tribes currently claim hunting rights within Yellowstone National Park, including the Shoshone-Bannock who roamed the western portion, the Crow who traversed the east, and some First Nations of Canada (Blackfoot, Blood, Piegan, and Assiniboine) who also hunted in the region.

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>
> Traditionally, bison provided food, clothing, fuel, tools, and shelter, and were central to Plains tribal spiritual culture. Bison were viewed as an earthly link to the spiritual world. For many tribes, bison represent power and strength.
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> Consumptive use of land and its resources and decimation of the bison herds helped to alter the interrelated world of both tribes and bison.

Treaties between the U.S. government and various tribes allowed the use of lands within the GYE by the tribes. Prior to park creation in 1872, the areas now known as Yellowstone National Park, Gallatin National Forest, Bridger-Teton National Forest, and Shoshone National Forest were reserved for some Plains tribes. The land west of the Yellowstone River was used traditionally by the Blackfeet tribes (Piegan and Blood), land to the southeast was part of the historic Crow territory, and the lands near the upper Missouri River were a common hunting ground for the above-mentioned tribes as well as the Gros Ventre, Flathead, Upper Pend d'Oreille, Kootenai, and Nez Perce tribes according to the 1851 Treaty of Fort Laramie. Seventeen years later, the 1868 Fort Laramie Treaty removed many acres of GYE land from tribal control, but allowed hunting in unoccupied lands. Shoshone and Bannock treaties did not include reference to the Yellowstone area, yet they lived and hunted there until the end of the 19th century.

Bison are critical to the indigenous cultures of North America and were an important part of the landscape covering more than half of the continent. In the historical period, products of the bison were important elements of intertribal and European-based trade. Traditionally, bison provided food, clothing, fuel, tools, and shelter, and were central to Plains tribal spiritual culture. Bison were viewed as an earthly link to the spiritual world. For many tribes, bison represent power and strength. For example, the Shoshone have expressed that spiritual power is concentrated in the physical form of the bison. Many contemporary tribes maintain a spiritual connection with bison. Consumptive use of land and its resources and decimation of the bison herds helped to alter the interrelated world of both tribes and bison.

The ethnographic record for Yellowstone National Park and the Gallatin National Forest is incomplete. Nabokov and Loendorf (2004) summarized a preliminary ethnographic overview and assessment for the park. Yellowstone National Park consults with 26 tribes or tribal organizations that are affiliated with the GYE (Table 7). Twenty of these 26 groups are current members of the Intertribal Bison Cooperative, which was organized in 1990 to restore the bison to Indian Nations and share knowledge about bison management.

Resource types that have been identified by park-related tribes as traditionally important and, therefore, potentially ethnographic resources include bison, wickiups, and stone alignments. Some of the stone alignments identified in the park and nearby areas are the remains of drive lines used to hunt bison and bighorn sheep. Tribal representatives also note that members of their tribes come to the park to collect certain plants for medicinal and ceremonial uses, as well as certain kinds of stone, such as obsidian. They also bring their children to the park to teach them about their own heritage.

Tribal representatives have informed NPS managers about many issues that are important to them concerning bison management actions during government to government consultations:

- Respectful treatment of the bison, including allowing them to roam freely without fencing or disrespectful hazing.
- Occurrence of brucellosis among elk and other free-ranging animals.
- Vaccine contamination of meat for consumption and ceremonial purposes.
- Measures to keep bison and cattle apart to minimize cross-infection.
- Frequency and effectiveness of vaccination delivery.
- Potential for transmission of brucellosis to humans.
- Distribution of live, seronegative bison to tribes. The FEIS for the IBMP indicates the partner agencies support the distribution of live bison that have completed an approved quarantine protocol to American Indian tribes, areas of public land, national park units, wildlife refuges, and approved research programs.
- If bison are to be killed, it should be done in a respectful manner.
- Distribution of bison meat, skulls, and hides to tribes.
- Preservation of wickiups, stone alignments, and other cultural features associated with bison.
- Employment of tribal interns in bison management programs.

While all of these issues are important to resolving short-term and long-term issues about bison management needs, the first six are most closely related to the bison vaccination program and this EIS.

Table 7. Tribes affiliated with the Yellowstone National Park area

Tribe	ITBC[1]	Historic Area	Associations
Assiniboine and Sioux Tribe[2], Fort Peck Tribes - ([N]Assiniboine; [D] Santee - Sisseton and Wahpeton; and Metis[3])	yes	Northeast Montana, Dakotas, Minnesota, Canada	Hunting grounds
Blackfeet Tribe[4]	yes	North and Central Montana	Treaty rights; traditional territory
Cheyenne River Sioux Tribe - ([L] Mnikoju, Itazipco, Siha Sapa, and Oo'henampa)	yes	Western Dakotas, Eastern Wyoming, Southeast Montana, Northwest Nebraska	Bison
Coeur d'Alene Tribe	no	Eastern Washington, Northern Idaho	Hunting grounds
Comanche Tribe of Oklahoma	yes	Southeast Colorado, Southwest Kansas, West Oklahoma, North Texas	Bison
Confederated Tribes of the Colville Reservation[5]	no	Northeast Washington	Hunting grounds
Confederated Tribes of the Umatilla Reservation[6]	no	Southeast Washington, Northeast Oregon	Hunting grounds
Confederated Salish and Kootenai Tribes, Flathead Reservation	yes	West Montana	Hunting grounds
Crow Tribe	yes	Northern Wyoming, Southern Montana	Treaty rights; traditional territory; traditional narratives
Crow Creek Sioux Tribe - ([D] Sisseton and Wahpeton; and [N] Yankton and Yanktonai)	yes	Eastern Dakotas and Minnesota	Bison
Eastern Shoshone Tribe, Wind River Reservation	no	Western Wyoming, Southeast Idaho	Traditional territory
Flandreau Santee Sioux Tribe - (D)	yes	Western Dakotas, Eastern Wyoming and Montana	Bison
Gros Ventre[7] and Assiniboine Tribes, Fort Belknap Indian Community	yes	North and Central Montana	Hunting grounds
Kiowa Tribe of Oklahoma	no	Southeast Colorado, Southwest Kansas, West Oklahoma, North Texas	Ancestral origins; bison
Lower Brule Sioux Tribe - ([L] Sicangu)	yes	Dakotas, Eastern Wyoming and Montana	Bison
Nez Perce Tribe	yes	North Idaho, Southeast Oregon, Northeast Washington	Hunting grounds
Northern Arapaho Tribe, Wind River Reservation	yes	Southeast Wyoming, Northeast Colorado, Northwest Kansas, Southwest Nebraska	Bison

Table 7. cont.

Tribe	ITBC[1]	Historic Area	Associations
Northern Cheyenne Tribe	yes	Southeast Wyoming, Northeast Colorado, Northwest Kansas, Southwest Nebraska	Bison
Oglala Sioux Tribe (L)	no	Northeast Wyoming, Southeast Montana, Dakotas, Northwest Nebraska	Bison
Rosebud Sioux Tribe - ([L] Sicangu or Upper Brule)	yes	Dakotas, Eastern Wyoming and Montana	Bison
Shoshone-Bannock Tribes, Fort Hall	yes	Southeast Idaho, Northern Utah	Treaty rights; hunting grounds
Sisseton-Wahpeton Sioux Tribe - ([N] Isanti - Mdewkanton, Wahpetowan, Wahpekute, and Sissetowan)	yes	Eastern Dakotas, Minnesota, Wisconsin, Iowa	Bison
Spirit Lake Sioux Tribe, Fort Totten - ([N] Isanti - Mdewkanton, Wahpetowan, Wahpekute, and Sissetowan)	yes	Eastern Dakotas, Minnesota, Wisconsin, Iowa	Bison
Standing Rock Sioux Tribe - ([L] Hunkpapa, Black Feet [Siha Sapa], [N] Hunkpatinas, and Cuthead Band of Yanktonai)	yes	Dakotas, Eastern Wyoming & Montana	Bison
Turtle Mountain Band of the Chippewa Indians	yes	North Dakota, Minnesota, Canada	Bison
Yankton Sioux Tribe - ([N] Yankton and Yanktonai)	yes	Eastern Dakotas, Minnesota	Bison

1. The Intertribal Bison Cooperative (ITBC) began in 1990 to restore the bison to Indian Nations and share knowledge about bison management. The tribes marked "yes" in this column are among the 51 current member tribes of the ITBC listed on their web site (ITBC 2005). Twenty of the 26 tribes affiliated with the Yellowstone National Park area, who are consulting with the NPS on the bison vaccination program, are member tribes of the ITBC. Many individuals from other member tribes are also participating as bison-interested individuals, or as members of the ITBC.
2. General grouping of Siouan tribes (based on information from the Cheyenne River Sioux Tribe [1999] web site and the Crow Creek Sioux Tribe community profile [Mni Sose Intertribal Water Rights Coalition 2005]):
   - Western Lakota (the L-dialect) Titonwan or Teton: Sicangu or Brule; Hunkpapa; Oglala; Mnikoju or Minneconjou; Itazipco or Sans Arc; Siha Sapa or Black Feet; Oo'henumpa or Two Kettle
   - Middle or Eastern Dakota (the D-dialect) Isanti or Santee: Sissetowan or Sisseton; Wahpetowan or Wahpeton; Mdewkanton; Wahpekute;
   - Northern and Southern Nakota (the N-dialect) Ihanktowan or Yankton: Yankton; Yanktonai; Assiniboine
3. The Metis, from a French word meaning mixed, presumably began as a loose confederation of free trappers of mixed European and American Indian ancestry. In the central provinces of Canada and northern fringes of the United States, including the Red River region of Manitoba, Minnesota, and North Dakota, they developed their own culture and identity.
4. The Blackfeet were historically a confederation of three Algonquian groups, the Piegan, Blood, and Northern Blackfeet (Blackfeet Nation 2005). The Blackfeet should not be confused with the Siouan Black Feet (Siha Sapa) Lakota. The Blackfeet Tribe in Montana is composed predominantly of Piegan. The other two tribes dominate the First Nations Blackfeet (or Blackfoot) of Canada.
5. The Confederated Tribes of the Colville Reservation are made up of 12 historic tribes: Coleville, Nespelem, San Poil, Lake, Palus, Wenatchee, Chelan, Entiat, Methow, Southern Okanogan, Moses Columbia, and Chief Joseph's Band of the Nez Perce (Confederated Tribes of the Colville Reservation 2000).
6. The Confederated Tribes of the Umatilla Reservation are made up of the Cayuse, Umatilla, and Walla Walla (Confederated Tribes of the Umatilla Indian Reservation 2005).

7. The Gros Ventre are an Algonquian group whose historical territory overlapped with the Blackfeet and the Siouan Assiniboine. The Gros Ventre are linguistically more closely related to the Arapaho and Cheyenne of the Plains (Fort Belknap Indian Community 2003).

3.8 Human Health and Safety

Bison can be a physical threat to humans if agitated. These animals may appear tame but are wild, unpredictable, and dangerous. Park handouts include warnings to visitors about approaching bison. Despite these warnings, many visitors have been gored by bison. Park employees from the Bison Ecology and Management Program frequently approach bison in their duties to track, count, fit radio collars, and conduct other wildlife management actions. Bison are most easily agitated during the rut (males) and when protecting calves (females). However, no direct injuries to employees engaging in bison management activities have occurred.

Brucella abortus is a natural human bacterial pathogen. There have been no cases of human undulant fever (i.e., human brucellosis) in Wyoming or Idaho attributed to wildlife (Greater Yellowstone Interagency Brucellosis Committee 1997). In Montana, there have been two confirmed cases of hunters contracting undulant fever from elk (Greater Yellowstone Interagency Brucellosis Committee 1997), with the last confirmed case occurring in 1995 (Zanto 2005).

Brucella abortus is classified as a Category B priority pathogen under the National Institutes of Health and National Institute of Allergy and Infectious Diseases. It is also considered an infectious agent under the Material Safety Data Sheet system because *Brucella* species are bio-hazardous materials. *Brucella abortus* is a Category A infectious substance under packaging and shipping regulations of the U.S. Department of Transportation, Centers for Disease Control and Prevention, and International Air Transport Association. *Brucella* species are considered Class III pathogens and are included on the list of bio-terrorist threat and biological warfare agents under the U.S. Department of Defense.

> *B. abortus* is a natural human bacterial pathogen.

3.9 Visitor Use and Experience

Visitation to Yellowstone National Park has fluctuated annually between two million and more than three million visitors during the last decade, with 3,151,342 visitors in 2007. Visitor use in Yellowstone National Park fluctuates seasonally. Recreation visitation is more concentrated during the summer months when roads are open, with 60-70% of recreation visitation occurring in June, July, and August. Wheeled-vehicle travel is limited to the far northern portion of the park during winter, when access to the interior is only via guided snow track vehicles. Access to the interior during spring and late autumn is by hiking, skiing, or bicycling on plowed roads.

> Visitation to Yellowstone National Park has fluctuated annually between 2 million and more than 3 million visitors during the last decade, with 3,151,342 visitors in 2007.

Summer visitor use patterns generally reflect entrance traffic and the tendency of visitors to drive to the major developed areas. Visitor use in the park is concentrated in Old Faithful, Canyon, and Mammoth Hot Springs. Old Faithful is the most popular developed area in the park, with 90% of visitors stopping at this area during 2006. Also, 69% and 64% of summer visitors reported visiting Mammoth Hot Springs and Canyon Village, respectively (Manni et al. 2007). The majority of recreation visitors traveled on or close to the road systems. The most common activities in the park were sightseeing/taking a scenic drive (96%) and viewing wildlife/bird watching (86%). Sightseeing/taking a scenic drive (59%) was the activity that was the primary reason for visiting the park (Manni et al. 2007).

Visitor accommodations are also concentrated in the developed areas. In the parts of the park that would be affected most by bison management alternatives, the Mammoth Hot Springs area has 223 hotel rooms and cabins and 85 campsites in the NPS-managed campground available for visitors, while the Tower-Roosevelt area has 80 cabins and a 32-site campground (out of a total of 2238 motel rooms and cabins and 2211 campsites park-wide). Approximately 4% of visitors stay in campgrounds where bison are likely to be observed nearby.

United States visitors to Yellowstone National Park were from California (12%), Utah (10%), Idaho (5%), Colorado (5%), Washington (5%), Texas (5%), and 43 other states and Washington, D.C (Manni et al. 2007). International visitors comprised 10% of the total visitation and were from Canada (25%), Netherlands (17%), Germany (10%), United Kingdom (9%), Italy (7%), and 17 other countries. Fifty-three percent of visitors were enjoying the park for the first time. Visiting the park was the primary reason that brought 60% of visitor groups to the area within 150 miles of the park (Manni et al. 2007).

Visitor Services project studies conducted through the NPS Social Science Program and run by the University of Idaho collect data on visitor services and satisfaction. Wildlife observation is one of the most popular activities for visitors to Yellowstone National Park. A survey of park visitors reported that wildlife observation was the most important activity during their visit, with 95% of respondents indicating participation in this activity (Duffield et al. 2000). Participation in wildlife observation exceeds participation for geyser viewing (87%), hiking (39%), bird watching (27%), camping (27%), and fishing (13%). Among park visitors in both the summer and winter surveys, about 50% said seeing bison was a reason for their trip (49% of resident summer visitors, 52% of nonresident summer visitors, and 54% of winter visitors). Furthermore, a portion of these respondents said they would not have made their trip to the park if bison had not been present (5% of resident summer visitors, 4% of nonresident summer visitors, and 7% of winter visitors; Duffield et al. 2000a, b).

Among park visitors in both the summer and winter surveys, about 50% said seeing bison was a reason for their trip. Furthermore, a portion of these respondents said they would not have made their trip to the park if bison had not been present.

Bison summer and winter ranges are generally located in valley lowlands of the major drainages in the park. This overlap of human and bison habitats provides visitors with year-round opportunities to view bison and other wildlife along park highways and at developed areas through the park. Because approximately 75% of visitors enter Yellowstone National Park through one gate and exit via another, most visitors pass through one or more valleys occupied by bison. Individuals and small groups of bison can be seen along all road segments at various times of the year. The major, observable effect of bison on existing visitor travel patterns is traffic jams created when visitors slow or stop to watch herds of bison cross park roads. Traffic jams several miles long and up to several hours in duration have been observed during mid-summer in the Hayden Valley.

Vehicle pullouts within the park are designed specifically for visitors to stop and experience the visual resources, including bison and other wildlife. Many of these pullouts are placed in areas where bison are most frequently found, with locations in Hayden Valley, Old Faithful/Firehole Basin, Madison River Valley, Norris to Mammoth corridor, Norris Campground, Gibbon Meadows, Elk Park, and Lamar Valley. These pullouts provide unobstructed views of natural habitat desirable to bison and other wildlife species. However, much of the park's bison habitat is not accessible by road travel. Therefore, visitation and viewing in these areas is relatively small.

Hiking trails and developments for pedestrians are located throughout occupied bison habitat. Campers and hikers in the backcountry, as well as day hikers, are likely to view bison in summer range areas. Walking trails and interpretive trails at Old Faithful and Canyon Village are located within bison occupied habitats (Figure 6).

Cross-country skiing and snowshoeing activities occur in bison winter ranges at Old Faithful, West Yellowstone, Blacktail Deer Plateau, Mammoth, Lamar Valley, and Norris. Winter use nearly doubled during the decade between 1984 and 1994, to 140,000 in the winter of 1994–95 (USDI and USDA 2000a). However, winter visitation depends on snow conditions and park regulations, which combined to limit snowmobile, snow coach, and skiing visitors during December 2008 through March 2009 to fewer than 43,000 (NPS 2009b). During the winter season, the majority of park visitors enter through the entrance near West Yellowstone, Montana. Little overnight backcountry use occurs in the winter. About 90% of visitors surveyed during winter 2008 indicated the opportunity to observe bison was an important factor in their visit, and that they were satisfied with their experience and the management of bison (Freimund et al. 2009).

3.10 Park Operations

The park is managed by a Superintendent and two Deputy Superintendents. The staff is organized into several operating divisions, including Concessions, Interpretation, Resource and Visitor Protection, Maintenance, Administration, and the Center for Resources. Most park funding comes from the annual appropriation of tax dollars allocated to the NPS by the U.S. Congress. Other funding comes from a portion of entrance fees the park is permitted to keep, and is generally earmarked for specific projects that support visitor activities.

> Approximately 25% of park funds are used for resource preservation, 18% for visitor services, 34% for facility operations and maintenance, and 23% for administration.

Park operations are those activities that need to be carried out routinely to meet the mission of Yellowstone National Park. These activities are varied and include research and monitoring of resources, engagement with the visiting public to educate them about park resources, the maintenance of roads, trails, and facilities, and administration of the staff. In fiscal year 2002, approximately 25% of park funds were used for resource preservation, 18% for visitor experience and enjoyment, 21% for facility operations, 13% for maintenance, and 23% for management and administration (NPS 2003).

To provide appropriate protection of the resources at Yellowstone National Park, research and management activities are conducted to learn more about the dynamic nature of park resources and how they fit together in the ecological processes of the GYE. Study and management of the resources is conducted by park staff and contractors and cooperators from all over the world. Preservation for future generations includes enforcement of the laws protecting these resources and protecting the safety of the visiting public. Park staff patrol the park and backcountry via vehicles, horses, boat, and on foot.

Much of the day-to-day interpretation and education within the park depends on interpretive programs presented by park rangers. Interpretative themes range from geology and human history to effective management of park resources, including bison. Educating the public is conducted by interpreting the ecological connections between biological and physical resources, as well as describing the cultural features. The Yellowstone Association was founded in 1933 to assist with educational, historical, and scientific programs that would benefit Yellowstone National Park and its visitors.

The NPS operates and maintains seven major developments and eight minor developments, plus seven campgrounds. Yellowstone National Park employs more than 500 people, requiring a significant administrative branch to manage the logistics of finance, purchasing, information transfer, and technical communications. Park staff maintains 710 buildings, while concessionaires maintain another 830 park-owned structures. The infrastructure connecting to these developments include water and sewage systems, 466 miles of roadway, and approximately 1,000 miles of trails. While operations occur throughout Yellowstone National Park, few large developments are located in the large blocks of bison habitat (Figure 6). The park has four primary contracts with concessionaires for food and lodging, merchandise sales, service stations, and medical care. The principal concessionaire for Yellowstone National Park, Xanterra Parks and Resorts, has had decades of experience in national parks. Summer operations include all of the park's nine lodging facilities, a recreational vehicle (RV) park, five campgrounds, restaurants, cafeterias, snack shops, lounges, gift shops, corrals, interpretive tours and a full-service marina on Yellowstone Lake. Winter operations include lodging at two in-park locations, restaurants, lounges, ski shops, ski and snowshoe tours, snow coach tours, cleaner and quieter four-stroke snowmobile rentals, educational adventure and wildlife tours, and photographic tours. Additional services are offered by Yellowstone Park Service Stations, Yellowstone Medical Services (Medcor, Inc.), and Delaware North Companies Parks & Resorts.

4. Chapter 4: Environmental Consequences

This chapter describes the methods and assumptions used to analyze impacts that could result from implementing the no action and action alternatives described in Chapter 2. The results of the analyses for each alternative, including the direct, indirect, and cumulative impacts, are described for each impact topic presented in Chapter 3. A summary of guiding laws, policies, and agency directives that affect how the impact topics are managed is provided in Appendix E.

4.1 Methods for Evaluating Impacts

This section describes the methods used to estimate impacts to resources. Impact topics were identified by internal scoping combined with input received during the public scoping process. Impacts are analyzed by considering the effects that each action may have on the impact topics described in Chapter 3. The discussion for each impact topic includes threshold definitions and an analysis of the impacts of each alternative, followed by an assessment of cumulative impacts. Possible mitigation measures are identified and factored into a concluding statement.

> A period of 15–20 years of implementation and monitoring may be required to determine how well the goals and objectives may be met. During this period, the bison population should fluctuate in abundance between 2,500 and 4,500 individuals, visitation to the park should continue to increase, and separation between bison and cattle should be maintained pursuant to the Interagency Bison Management Plan and subsequent adaptive management adjustments.

A period of 15-20 years of implementation and monitoring may be required to determine how well the goals and objectives may be met by the selected alternative (Ebinger and Cross 2008, Appendix I), though this time-period may be reduced if surveillance is focused on 2-3-year-old animals (White et al. 2008). During this period, the bison population should fluctuate in abundance between 2,500 and 4,500 individuals, visitation to the park should continue to increase, and separation between bison and cattle should be maintained pursuant to the IBMP and subsequent adaptive management adjustments (Plumb et al. 2009).

4.1.1 Types of Impacts

The generalized approach for analyzing each impact topic is to define the issues of concern as discovered through scoping and consultation; to identify the area of potential effects to resources, NPS values, and visitor experiences; and, subsequently, to disclose those effects that are likely to occur under the scenarios described by each of the proposed alternatives. The effects are characterized from a variety of perspectives. Potential impacts are described in terms of type (i.e., beneficial or adverse, direct or indirect), context (i.e., local or regional), duration (i.e., short-term or long-term, seasonal or continuous), and intensity (i.e., negligible, minor, moderate, or major). The following definitions were applied for all impact topics:

- *Beneficial impact*—a positive change in the condition or appearance of the resource or a change that moves the resource toward a desired condition.
- *Adverse impact*—a negative change in the condition or appearance of the resource or a change that moves the resource away from a desired condition.

- *Direct impact*—an effect that is caused by an action and occurs in the same time and place.
- *Indirect impact*—an effect caused by an action that is removed in time or distance from the action, but is still reasonably foreseeable.
- *Site-specific impact*—the action would affect relatively small areas within the park, centered on where the action takes place.
- *Local impact*—the action would affect areas within the park boundary.
- *Regional impact*—the action would affect resources in the park, on lands adjacent to the park, and in surrounding communities.
- *Short-term impact*—consequences of the action that are short in duration and not detectable after a resource returns to the pre-implementation condition.
- *Long-term impact*—consequences of the action that result in a lasting or nearly permanent change in resource conditions.

The magnitude of effect is categorized into four levels of intensity: negligible, minor, moderate, and major. Threshold values for these four categories are described in each impact section and defined based on management objectives, consultation with tribal advisors and regulatory agencies, the public scoping process, and conversations with subject matter experts.

4.2 Incomplete and Unavailable Information

Section 40 CFR 1502.22 of Council of Environmental Quality regulations and Section 4.5 of DO-12 allows for a discussion of incomplete and unavailable information and how to include those data in analyses. The following paragraphs address this topic through 1) an explanation of incomplete or unavailable information; 2) an explanation on the relevance of this information for evaluating reasonably foreseeable significant adverse impacts; and 3) a summary of scientific studies relevant to evaluating reasonably foreseeable significant adverse impacts which are disclosed further on in Chapter 4.

The current state of technology provides for a limited number of vaccines for use in brucellosis management. Likewise, there are limited options for delivery of the available vaccines. In addition, many of the current diagnostic tools have been extrapolated from livestock for use in wildlife without rigorous evaluation (Aune et al. 2002, U.S. Animal Health Association 2006). Recognizing the regional and national importance of this issue, the U.S. Animal Health Association organized a working symposium at the University of Wyoming in Laramie during 2005 to identify the most important opportunities and costs for improved vaccines, vaccine delivery systems, and disease testing for brucellosis in bison and elk. Some of the major recommendations from this symposium included:

- Strain RB51 offers only "moderate" (term not defined in document) protection in bison. Thus, there is a need to conduct clinical challenge trials on SRB51 plus, Strain 82, and other potential vaccines, develop a rapid assessment protocol to screen additional promising vaccine candidates, and develop and license new vaccines engineered specifically for elk and/or bison.

- Oral and remote ballistic delivery methods require improvements, including achieving sustained release, creating effective bio-markers to evaluate vaccine delivery, improving vaccine stability and storage/shelf life, and optimizing vaccine dosage.
- Field validation trials should be conducted to evaluate effectiveness of vaccine delivery before widespread application of vaccination programs in the GYE.
- Validate existing brucellosis diagnostic methods that are applied to wildlife.
- Initiate new research to develop and validate new technologies such as rapid genomic diagnostic tests involving Polymerase Chain Reaction (PCR) and vaccine bio-markers.

Extensive literature review and discussion with subject area experts has revealed no progress on new vaccines, delivery technologies, or diagnostic tests to date due to the lack of market incentives and funding. We are not aware of any available test that conclusively or reliably detects active infection of *Brucella abortus* in live bison. Laboratory testing of DNA blood samples suggests that application of the PCR assay for *Brucella abortus* may be inaccurate and misleading in bison for detecting exposure or active infection, as results in bison have largely been negative (i.e., no positive DNA results compared to culture results indicating infection from the same animals; Roberto and Newby 2007).

Vaccines are typically designed to either prevent the establishment of disease infection or reduce the probability of disease transmission. Ideal vaccines that prevent infection upon exposure to the disease are seldom available. Thus, imperfect vaccines are often used to reduce the severity of disease or pathogen transmission potential. However, using less effective vaccines or delivering the vaccine to a relatively small proportion of the eligible animals can lead to adaptive changes in the disease pathogen that select for variants able to evade the immunological response induced by the vaccine. These vaccine-adapted variants can then spread in the population, reduce the efficiency of the vaccination program, and result in longer-term evolutionary changes in the host-pathogen association. To reduce these problems, highly efficient vaccines should be quickly delivered to a large proportion of the eligible animals to lead to disease suppression or eradication (Gandon et al. 2001, 2003; Andre et al. 2006).

In bison, the vaccine SRB51 is an imperfect vaccine that does not offer protection from *B. abortus* infection, but provides intermediate protection (~80%) from *B. abortus* transmission.

In bison, the vaccine SRB51 is an imperfect vaccine that does not offer protection from *B. abortus* infection, but provides intermediate protection (~80%) from *B. abortus* transmission (Olsen et al. 2003). However, *B. abortus* has an effective life history strategy whereby the bacteria replicate when signaled by high levels of pregnancy hormones and hide within the cytoplasm of the lymph node cells during periods of inactivity. Also, the bacteria can evolve adaptive strategies to survive by evading antibody attacks and through genetic changes in their chemistry that lead to successful natural selection processes. These aspects of SRB51 and the life history of *B. abortus* may provide a selective advantage for bacteria whereby SRB51 vaccination becomes ineffective leading to an increase in transmission potential, stronger persistence within the bison host, and greater pathogenicity (i.e., virulence or degree of intensity of the disease produced by a pathogen). This potential adaptation of *B. abortus* to SRB51 could be exacerbated if delivery via remote vaccination is hampered due to logistics or bison behavior and only a relatively small proportion of the eligible females are vaccinated. The speed at which *B. abortus* can adapt to bison immune responses induced by SRB51 will depend on the genetic variation of *B. abortus* in Yellowstone's wildlife and the selection pressure from SRB51. Similar uncertainties exist for all vaccination programs and the surveillance program (Appendix H) and adaptive management process will be used to mitigate potential adverse effects.

Davis and Elzer (1999, 2002) concluded that SRB51 had little efficacy in adult and calf bison despite repeated vaccinations. In contrast, Olsen et al. (2003) reported that vaccination of bison calves offered protection against intra-mammary and fetal infection in non-aborting vaccinates, as well as protection from abortions and placental infection.

Delivery of vaccine to Yellowstone bison in late winter may be ineffective at inducing an effective immune response owing to their under-nourished and stressed condition.

There are several other uncertainties regarding the effectiveness of vaccination for Yellowstone bison. Adequate diet quality is important for stimulating and maintaining immune system function. However, nearly all plants used as forage by large herbivores (e.g., bison) inhabiting temperate climates at high latitudes (e.g., Yellowstone National Park) are dormant during winter and, as a result, the nutritional value of winter diets cannot meet maintenance requirements (Hobbs et al. 1981). This sub-maintenance forage quality, combined with reduced forage availability and increased energetic costs due to snow pack (Parker and Robbins 1984, Wickstrom et al. 1984), results in chronic nutritional deprivation each winter and induces physiological changes and stress responses via hormone production. Stress can cause suppression of immune system function. Thus, delivery of vaccine to Yellowstone bison in late winter may be ineffective at inducing an effective immune response owing to their under-nourished and stressed condition. In turn, when bison are later challenged by natural exposure to *B. abortus*, the immune system may be unable to mount an effective response. The period of highest exposure to brucellosis in late winter likely coincides with the period of lowest immune competence in bison (ability of the immune system to respond appropriately to an antigen by producing and antibodies which will combat the foreign substance). Thus, late winter exposure to *Brucella* can be difficult for any animal to produce an effective immune response, regardless of whether they are vaccinated or not (see USAHA Scientific Committee response to questions about uncertainty below).

Olsen et al. (2009) characterized immunologic responses and protection against experimental challenge after vaccination of 11-month-old bison with *B. abortus* SRB51 or a recombinant RB51 strain (SRB51+). When compared to non-vaccinates, bison vaccinated with SRB51 or SRB51+ had significantly greater antibody responses, proliferative responses, and production of interferon-γ to SRB51 after vaccination. Contrary to SRB51+ vaccinates, bison vaccinated with SRB51 had greater protection from abortion, fetal/uterine, mammary, or maternal infection as compared to non-vaccinates. These findings suggest that the SRB51+ strain is less efficacious as a calf-hood vaccine for bison compared to vaccination with the original SRB51 strain. The authors suggest the SRB51 vaccine is a currently available management tool that could be used to help reduce brucellosis in free-ranging bison.

At the present time, experimental data for hand vaccination of bison with SRB51 suggests a 50–60% reduction in abortions, 45–55% reduction in infection of uterine or mammary tissues, and a 10–15% reduction in infection.

Olsen et al. (2006) reported the ballistic inoculation of bison with biobullets containing photopolymerized, poly(ethylene glycol)-based hydrogels induced a significant cell-mediated immune response similar to hand injection of the vaccine via syringe. In contrast, the immunologic responses of bison to hydrogel vaccination with SRB51 during 2007 indicated poor proliferation and interferon response compared to syringe injection (Olsen 2008). We suspect these different results were due to differences in the photopolymerization process used to encapsulate vaccine in projectiles. Thus, we are collaborating with the University of Utah to develop procedures to guide vaccine encapsulation work and maintain the consistency and quality necessary for effective field vaccination experiments and eventually an operational remote vaccination program.

Experimental vaccine efficacy studies are difficult to compare with large-scale remote vaccination of Yellowstone bison because the virulence, infectious dose and delivery method of the pathogen is controlled to identify conditions where vaccine protection fails. These conditions may not be similar to what is experienced by free-ranging Yellowstone bison. However, yearling bison in Yellowstone National Park showed favorable cell-mediated immune response (i.e., proliferation of T lymphocyte subsets) to syringe vaccination with SRB51 near the end of the moderate 2008 winter (Treanor 2008).

> The brucellosis issue in Yellowstone bison presents managers with the challenge of making some decisions based on uncertain information. The need to make decisions in the face of uncertainty makes models insightful tools into how systems might behave under specified management actions.

During a 2005 symposium at the University of Wyoming, Professor Konstantin Mikhailovich Salmakov presented Russian approaches for preventing brucellosis in cattle. Dr. Salmakov reported that in Russia a live vaccine based on *B. abortus* 82 (Russia, ARVI, Kazan) is in use currently as an officially approved preparation. Strain *B. abortus* 82 was developed in 1960 by Professor Salmakov. Broad application of the strain 82 vaccine, providing a strong immune response and possibility of early post-vaccinal diagnostics (after 3-6 months compared to 2-3 years after strain 19), made it possible to reduce epizootic (i.e., a disease of sudden onset within an animal population with reasonable probability of infecting humans in close proximity) outbreaks of cattle brucellosis in Russia. The number of brucellosis positive premises decreased. The large reduction in new cases of brucellosis encouraged the Head Veterinarian Directorate at the Ministry of Agriculture to approve the live strain 82 vaccine for use in veterinarian practice for fighting cattle brucellosis. For over 30 years, the biological industrial complex in Shchelkovo (Moscow region) has been producing dry strain 82 vaccine which has been successfully applied in many regions of Russia as an integral part of the veterinary-sanitary program for control of cattle brucellosis. By the end of 2004, after taking special measures including application of the vaccine in cattle, the number of places with brucellosis was decreased to 1.4% of its 1974 level. Positive results were also achieved for application of the vaccines in other animal species (e.g., reindeer (*Rangifer tarandus*), maral (*Cervus elaphus*), yak (*Bos grunniens*), buffalo (*Bison bonasus*), and zebu (*Bos primigenius indicus*). Dr. Salmakov reported that with the use of strain 82 vaccine, the problem of brucellosis in many regions of Russia has been solved. Unfortunately, these findings and claims have not been subject to peer-review or published in science journals for closer scrutiny. Efforts are currently underway to locate, organize, archive, analyze, interpret, and publish in peer-reviewed journals the data from these comparative laboratory research and field trials on strain 82. However, even if the data appears promising, it will likely take decades to adequately test this select agent (especially given the lack of large animal facilities for testing) and gain approval for experimental use in wildlife.

On October 25, 2008, during the 112th Meeting of the United States Animal Health Association, the Scientific Advisory Subcommittee on Brucellosis offered responses to six focal questions posed by staff from Yellowstone National Park regarding the vaccination of bison for brucellosis with SRB51. Subcommittee Chair Phillip Elzer summarized the subcommittee's comments in the following paragraphs, which were included in their report to the Committee on Brucellosis (Plumb and Barton 2008), recognizing that sufficient data is generally lacking to make specific recommendations. Subcommittee members were Don Davis, Phillip Elzer, Don Evans, Barb Martin, Steve Olsen, Jack Rhyan, and Gerhardt Schurig.

1. *What level of vaccine efficacy can be expected in Yellowstone bison compared to experimental studies?* It was discussed that the protective effects of a vaccine under field conditions may be influenced by a number of factors including, but not limited to, nutrition, environmental stress, percentage of the population vaccinated, and co-infection with other pathogenic agents. It was discussed that if all parameters are the same, protection under field conditions is most likely to be similar to protection under experimental conditions. However, it was also discussed that efficacy under field conditions may be greater as all animals are not exposed with an infectious dosage at the most susceptible time. At the present time, experimental data for hand vaccination of bison with SRB51 suggests a 50-60% reduction in abortions, 45-55% reduction in infection of uterine or mammary tissues, and a 10-15% reduction in infection. Committee members are reluctant to specifically predict field efficacy of current vaccines due to the multiple factors that may influence protection as mentioned above, and suggest that scientific studies be initiated if specific measurements of protection are needed.

2. *Can similar vaccine efficacy be expected from remote delivery compared to syringe delivery?* In general, committee members discussed the fact that currently available data suggests that remote delivery induces protection that is less than hand vaccination. The scientific basis for this reduction has not been specifically identified but multiple factors were discussed that may be influencing the current observations. For reasons similar to those discussed above for vaccine efficacy, the committee cannot place a specific numeric value on the reduction.

3. *Is it safe to vaccinate pregnant bison prior to mid-gestation?* Although scientific data is limited, the committee felt that when compared to the risk associated with the possibility of infection and abortion caused by field strains of *B. abortus*, risks associated with administration of vaccines strains to Yellowstone bison are not significant. The committee discussed the fact that abortions have been documented in bison with SRB51 and Strain 19. It was discussed that unknown factors may influence the incidence of abortions caused by *Brucella* vaccine strains. Two committee members discussed studies in which they were unable to

> The committee recommends that vaccination of bison be timed to provide a minimum of 12-14 weeks prior to the anticipated dates of exposure to virulent field strains of *B. abortus.*
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> The committee discussed that due to the time for *Brucella* vaccines to be cleared from bison, it was unlikely that frequent vaccination would be beneficial.

induce abortions in pregnant bison with SRB51 in safety studies involving single or multiple dosages. The committee is currently unable to provide specific numeric estimates for abortions in pregnant bison induced by brucellosis vaccines.

4. *What is the best time of year to maximize vaccine efficacy?* The committee discussed that, with the exception for the influence of nutritional or environmental stress, it was anticipated that responses to calfhood vaccination would be similar. It was also discussed that pregnant bison may be less responsive to vaccination particularly around the time of birth. The committee recommends that vaccination of bison be timed to provide a minimum of 12-14 weeks prior to anticipated dates of exposure to virulent field strains of *B. abortus*.

5. *How frequently should bison be vaccinated?* The committee discussed that due to the time for *Brucella* vaccines to be cleared from bison, it was unlikely that frequent vaccination would be beneficial. The committee discussed that annual vaccination of all female bison would most likely be most beneficial for maintenance of maximal protection.

6. *Can bison be vaccinated too often?* The committee discussed that scientific data on multiple vaccination of bison is very limited. Excluding the possibility of syndromes associated with hyper-immunization, it was assumed that multiple vaccinations would be safe in bison. However, as discussed above, the committee questioned how beneficial administration of multiple vaccinations would be.

Assumptions to compare and evaluate remote delivery vaccination alternatives:

- The efficacy of current *B. abortus* vaccine for bison will be intermediate between the levels identified in experiments.
- Not all bison targeted for vaccine will receive a dose in any given year.
- Not all vaccinated bison will exhibit an immune response.
- Over time, new methods will result in more efficient delivery to the same number or a higher percentage of eligible bison.

Moving forward with an aggressive vaccination program of bison in Yellowstone National Park depends on scientists within and outside the NPS addressing the uncertainties identified by the U.S. Animal Health Association (2006) and others to improve the effectiveness of vaccines, vaccine delivery methods, and disease testing. All of the above discussion on incomplete and unavailable information is relevant to evaluating reasonably foreseeable significant adverse impacts. Given the difficult means to obtain this information, surveillance and adaptive management based on monitoring results became a major element of the remote vaccination program.

In the interim and based on the above discussions on uncertainty and unavailability of information, the following assumptions were made to compare and evaluate remote delivery vaccination alternatives:

- The efficacy of current *B. abortus* vaccine for bison will be intermediate between the levels identified in experiments (Davis and Elzer 1999, 2002; Olsen et al. 2003).
- Not all bison targeted for vaccine will receive a dose in any given year.
- Not all vaccinated bison will exhibit an immune response.

- Over time, new methods will result in more efficient delivery to the same number or a higher percentage of eligible bison. Vaccine technology will evolve to produce improved vaccines that are lower risk for human handling and more efficient at conveying an acquired immune response.

4.3 Cumulative Impacts

Federal regulations require an assessment of the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions (40 CFR 1508.7). These cumulative impacts for each alternative were analyzed by combining the direct and indirect impacts of each impact topic with other past, present, and foreseeable future actions within Yellowstone National Park and conservation areas adjacent to the park in the State of Montana (USDI and USDA 2000b). Actions include any planning or development activity that was currently being implemented or would be implemented in the reasonably foreseeable future that (1) has some relation to bison populations and management, (2) impact the quantity, quality and access to bison habitat, and (3) would contribute to cumulative effects within the designated area of analysis for this EIS. These actions include:

- Other vaccination efforts at capture facilities.
- Other risk management actions including hazing and capture and lethal removal of bison.
- Reconstruction of East Entrance Road (underway), Gibbon Canyon (proposed), Dunraven Pass (first half completed, second half proposed), Canyon rim drives (underway), and Mammoth-Norris road (proposed).
- Construction of a new Lamar River Bridge (on the Northeast Entrance road) to replace current deficient bridge.
- Construction in the vicinity of the Tower-Roosevelt junction in association the Tower-Roosevelt Comprehensive Plan.
- Winter use in the parks and changing restrictions on winter visitor use.
- Construction of the Old Faithful Visitor Education Center.
- Motorized visitor use on forest and private lands outside the parks.
- Increasing outfitter/guide activity - Visitors are increasingly using outfitters and guides, especially for skilled or knowledge-based activities like wildlife viewing, and photography.
- Population growth in the GYE - This area has been experiencing rapid population growth for the last 20 years. Such growth can lead to more recreation in wildlife habitat and more development in current areas of open range.

- Gardiner Basin and Cutler Meadows restoration - The USFS and NPS are restoring native plants to these areas where bison move in winter months.
- Noxious weed growth - Noxious weeds can impact forage available to ungulates.
- Agricultural Landscapes - Cattle grazing and supplemental irrigation of valley bottom private lands will continue.

The fundamental purpose of the NPS, established by the Organic Act and reaffirmed by the General Authorities Act, as amended, begins with a mandate to conserve park resources and values.

Impairment is an impact that, in the professional judgment of the responsible NPS manager, would harm the integrity of park resources or values, including opportunities that would otherwise be present for the enjoyment of those resources or values.

4.4 Impairment

The fundamental purpose of the NPS, established by the Organic Act and reaffirmed by the General Authorities Act, as amended, begins with a mandate to conserve park resources and values. NPS managers must always seek ways to avoid or minimize adverse impacts on park resources and values to the greatest degree practicable (NPS 2006). However, the laws give NPS managers some discretion to allow impacts to park resources and values when necessary and appropriate to fulfill the purposes of a park. This discretion is limited by statutory requirement that the NPS must leave park resources and values unimpaired unless a particular law directly and specifically provides otherwise. Impairment is an impact that, in the professional judgment of the responsible NPS manager, would harm the integrity of park resources or values, including opportunities that would otherwise be present for the enjoyment of those resources or values. Impairment may result from NPS activities related to managing the park, visitor activities, or activities undertaken by concessionaires, contractors, and others operating in the park. A determination on impairment is made in the *Conclusion* section for each of the resource topics carried forward in this chapter, except for Human Health and Safety, Visitor Use and Experience, and Park Operations. An impact would more likely constitute impairment to the extent that it affects a resource or value whose conservation is:

- Necessary to fulfill specific purposes identified in the establishing legislation or proclamation of the park.
- Key to the natural or cultural integrity of the park or to opportunities for enjoyment of the park.
- Identified as a goal in the park's Master Plan, General Management Plan, or other relevant NPS planning documents.

4.5 Unacceptable Impacts

The threshold at which impairment occurs is not always apparent. Virtually every form of human activity that takes place in a park has some degree of effect on resources or values. This does not mean that an impact is unacceptable or that a particular use must not occur. Policy directs that the NPS will avoid impacts determined to be unacceptable. These would be impacts that fall short of impairment, but are still not acceptable within the environment of the park. A determination on unacceptable impacts is made in the *Conclusion* section for each of the resource topics carried forward in this chapter. Unacceptable impacts would individually or cumulatively:

- Be inconsistent with a park's purposes or values.
- Impede the attainment of a park's desired future conditions for natural and cultural resources as identified through the park's planning process.
- Create an unsafe or unhealthy environment for visitors or employees.
- Diminish opportunities for current or future generations to enjoy, learn about, or be inspired by park resources or values.
- Interfere unreasonably with park programs or activities, result in an inappropriate use of the park, or alter the atmosphere of peace and tranquility by disturbing the natural soundscape.

4.6 Evaluation of Impact Topics

4.6.1 Impacts to the Yellowstone Bison Population

Impacts expected to influence Yellowstone bison are described based on a review of the literature, knowledge attained by members of the Bison Ecology and Management Program at Yellowstone National Park and other scientists and stakeholders, and quantitative information provided by an analysis model developed specifically for this assessment.

The geographic area of analysis for the bison population includes habitats within and adjacent to Yellowstone National Park where bison are afforded habitat under the IBMP. The transmission of brucellosis from bison to cattle requires that infected, pregnant bison shed *B. abortus* outside the park during a *Brucella*-induced abortion or infectious live birth, and that a susceptible domestic cow encounters the shed bacteria by (1) licking infectious birth tissues, or (2) grazing on vegetation where *B. abortus* has been left behind as the amniotic fluid is dispersed during the birthing process. Suitable winter range for bison extends onto public lands outside Yellowstone National Park, where cattle may encounter shed bacteria. Concern over the risk of brucellosis transmission to cattle drives the need to prevent commingling with bison. The intent of vaccination is to reduce brucellosis infection in Yellowstone bison and, as a result, further reduce the risk of transmission to cattle outside the park.

Impacts to bison management change the risk of brucellosis transmission to other bison and to cattle outside the park. The thresholds of intensity used to describe the impacts of the proposed actions are as follows:

- *Negligible*—impacts would be slight to undetectable.
- *Minor*—impacts would be detectable, but only to a small portion of the population, and brucellosis prevalence would likely decrease by 5-10% below estimated baseline levels.
- *Moderate*—impacts would be detectable in a modest portion of the population, and brucellosis prevalence would likely decrease by 11-50% below estimated baseline levels.
- *Major*— impacts would be detectable throughout the population, and brucellosis prevalence would likely decrease by greater than 50% below estimated baseline levels.

The brucellosis issue in Yellowstone bison presents managers with the challenge of making some decisions based on uncertain information. The need to make decisions in the face of uncertainty makes models insightful tools into how systems might behave under specified management actions. System dynamics modeling is used to simulate complex environmental systems and improve understanding of the interactive components of a system and how they function (Ford 1999). Modeling is an essential part of an effective adaptive management program (Williams et al. 2007). Precise predictions are rare due to uncertain parameters that are difficult or impossible to measure. However, management models provide decision makers with information to compare the relative effects from proposed alternatives.

Holding bison in an enclosure increases the risk of brucellosis transmission if an abortion or infectious live birth occurs.

A stochastic, individual based model (see Glossary) was developed for this analysis to simulate the epidemiology (or study of factors and mechanisms involved in the spread) of brucellosis infection in Yellowstone bison (Treanor et al. 2007a). Outputs were produced from model simulations corresponding to the three proposed alternatives. A summary of how the analysis model was developed, parameterized, and used to provide output is included (Appendix J). The model provided information on the relationship of two responses that are difficult to monitor (i.e., infectious events and vaccine protected bison) and two that can be monitored (i.e., population seroprevalence and the proportion of bison removed for slaughter). All four of these results are correlated, but only population seroprevalence and the numbers of bison removed are outcomes that can be effectively monitored. Decreases in population seroprevalence will result in fewer seropositive bison involved in management operations at the park boundary. The rate of seroprevalence decrease results from the vaccination effort described in each alternative. As more bison become vaccine protected, less infectious material is shed onto the landscape, thereby decreasing the likelihood of exposure. Model projections of these four results were used as criteria for quantifying the impacts of the three alternatives.

4.6.1.1 Impacts from Alternative A (No Action—Boundary Capture Pen Vaccination of Calves and Yearlings)

During capture operations, bison congregated in the holding paddocks have the potential to become injured by running into facility walls or other bison, or by aggressive behavior toward other individuals. Injuries may include breaking horns on hard structures or being gored by other herd members. Also, intensive management operations often occur during winter months when bison energy reserves are low and snow conditions limit forage availability. Captured bison may be more susceptible to injury during mid- to late-winter because of decreases in their physical condition. Based on previous bison capture operations conducted at Stephens Creek, indirect, short-term, adverse, localized, minor impacts would result to bison from injuries during capture operations (i.e., moving, holding, and immobilizing).

Under Alternative A, indirect, short-term, beneficial, minor impacts on reducing the risk of *B. abortus* shed within specific management zones would be localized as a result of the small proportion of bison that are vaccine protected.

Calf and yearling bison captured at the pens may be hand-injected with brucellosis vaccine. A common side effect from syringe delivery of vaccine is swelling at the injection site and lethargy for a day or two following vaccination (Goelz 2000). Though this type of vaccine delivery has very low potential for extensive bleeding and tissue damage or anaphylactic reaction, it does require immobilizing bison in a squeeze chute. Physically restraining bison elevates stress levels and makes them more susceptible to injury. The direct, short-term, adverse impacts of tissue trauma resulting from hand vaccination of bison would be negligible. After being released following vaccination, indirect, short-term, adverse impacts to bison resulting from possible infection, increased predation risk, and injury from other herd members would be negligible due to little tissue damage from syringe vaccination.

Vaccine SRB51 is considered low risk for reproductively immature bison (Olsen et al. 1997, 1998; Davis and Elzer 2002). However, the duration of protection offered by SRB51 is uncertain and a single dose of SRB51 given to calves and yearlings is not expected to provide lifetime protection. Since this alternative targets only a small proportion of young bison, these individuals would not receive additional vaccinations aimed at extending the time period for vaccine protection. The ability of *B. abortus* to persist in the host for long time periods raises concerns that latent infected bison may again become susceptible to active infection later in life. These animals have the potential to relapse and become infectious, thereby shedding *B. abortus* when calving. Also, holding bison in an enclosure increases the risk of brucellosis transmission if an abortion or infectious live birth occurs. Therefore, the indirect, long-term, beneficial, impacts on the duration of vaccine protection would be minor.

> Implementation of Alternative A would result in vaccinating a small proportion of the bison population.
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> Access to bison for syringe delivery of vaccine at the capture pens will be limited and the number of vaccinated bison that receive protection from the vaccine would be less than 1% over the 30-year simulation period. Even with a highly effective vaccine, the small proportion of bison vaccinated would likely have a minimal effect on reducing brucellosis infection in the population.
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> Alternative A would have little impact on reducing infection and managing transmission risk to cattle.

Implementation of Alternative A would result in vaccinating a small proportion of the bison population (i.e., calves and yearlings that move to the park boundary; Figure 9). Some bison make regular migratory movements to low-elevation winter ranges near the park boundary, where they could be captured in existing facilities during late winter. However, a substantial proportion of bison do not migrate to the boundary area during winters when bison density is relatively low and snow pack is approximately average (Cheville et al. 1998, Kilpatrick et al. 2009). Thus, access to bison for syringe delivery of vaccine at the capture pens will be limited and model simulations suggest the number of vaccinated bison that receive protection from the vaccine would be less than 1% over a 30-year period. Even with a highly effective vaccine, the small proportion of bison vaccinated would likely have a minimal effect on reducing brucellosis infection in the population. Also, the number of bison vaccinated in a given year is highly variable because it depends on the number of young bison that migrate outside the park, are captured, and test seronegative for brucellosis exposure. Model simulations for Alternative A estimated a reduction in brucellosis seroprevalence in the bison population from the initial state of about 47% to about 35% (i.e., about a 25% decrease [(1 – 35/47)*100]) over a 30-year period (Figure 10). This level of reduction offers a minor degree of protection from *Brucella*-induced abortions and, as a result, moderate levels of infectious events are expected to occur within the population over the 30-year simulation period. Implementation of Alternative A should have a minor to moderate influence on the number of seropositive bison removed during capture operations at the park boundary. Model simulations estimated about a 33% decrease in the number of seropositive bison removed during capture operations at the park boundary over a 30-year period.

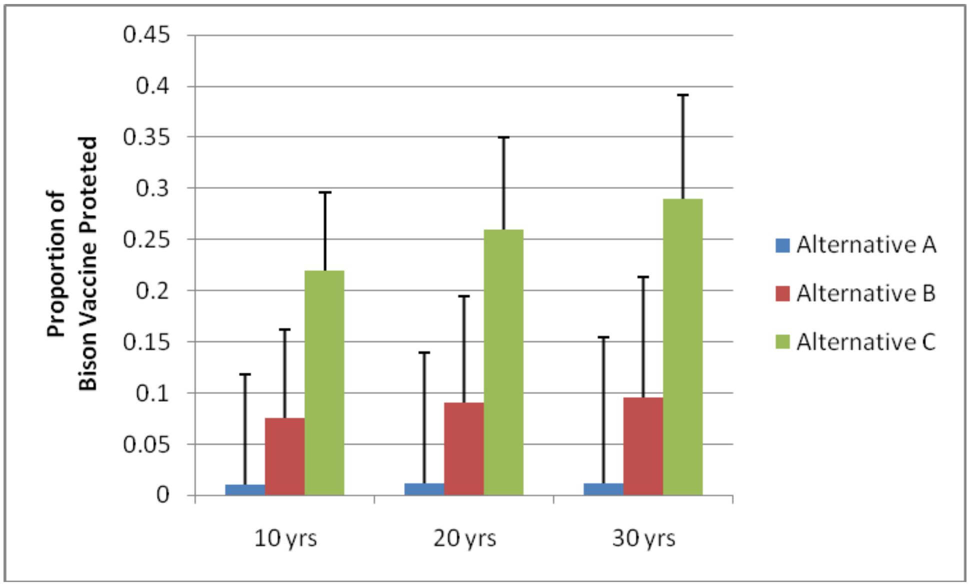

Figure 9. Model comparisons of the proportion of vaccine-protected bison for the three vaccination alternatives based on an intermediate (50%) level of vaccine efficacy. Error bars indicate the standard deviation of the mean (i.e., variation in individual model runs relative to the average values presented in the bar plots).

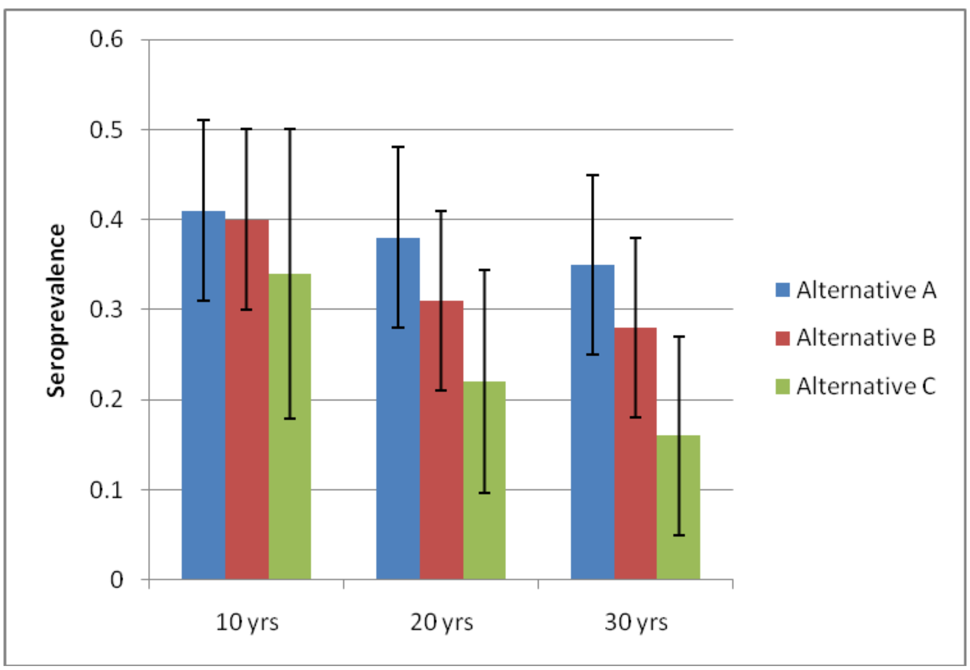

Figure 10. Model comparisons of brucellosis seroprevalence decreases for the three vaccination alternatives at 10-, 20-, and 30-year intervals. Error bars indicate the standard deviation of the mean (i.e., variation in individual model runs relative to the average values presented in the bar plots).

The fewer animals that are vaccine protected, the greater the risk of transmitting brucellosis to cattle. Consequently, Alternative A would have little impact on reducing infection and managing transmission risk to cattle. Impacts would be direct, short-term, beneficial, and minor in reducing the amount of *B. abortus* shed on the landscape. Indirect, short-term, beneficial, minor impacts on reducing the risk of *B. abortus* shed would be localized within specific management zones. Indirect, long-term, beneficial impacts on the duration of vaccine protection would be minor. Indirect, beneficial, minor impacts influencing the risk of brucellosis transmission to other bison and cattle in these localized management zones would result in the short-term.

The bison population would receive direct, short-term, beneficial, minor impacts toward increasing the level of protection from brucellosis infection (i.e., herd immunity). Because of the low number of animals annually vaccinated, there would be direct, short-term, beneficial, minor impacts on the reduction of brucellosis seroprevalence (Figure 10). The long-term impact on seroprevalence decrease is expected to be moderate (Table 8). Since the focus of the vaccination effort is on reproductively immature animals, there would be no short- or long-term impacts resulting in vaccine-induced abortions and subsequent transmission risk to susceptible individuals. A high percentage of these immature animals are expected to receive protection from aborting their first pregnancy should they become exposed to field strain *B. abortus* prior to the end of their first pregnancy.

Table 8. Percent brucellosis seroprevalence decrease for each alternative in 10-year increments

Time into vaccination program	Alternative A	Alternative B	Alternative C
10 Years	13	15	28
20 Years	19	34	53
30 Years	25	40	66

Following brucellosis infection, 96% of bison females are expected to abort their first pregnancy (Olsen et al. 2003). Therefore, the disease may affect bison calving rates and, in turn, the rate of population growth (Fuller et al. 2007b, Geremia et al. 2009). The vaccine SRB51 is anticipated to partially protect bison from *Brucella*-induced abortions (Olsen and Holland 2003). Since model simulations demonstrate a small reduction in population seroprevalence under Alternative A (Figure 10), this level of reduction is likely to have a correspondingly small influence on bison calving rates and population growth. Therefore, indirect, short-term, beneficial, minor impacts to the population's calving rate are expected to result from vaccine protection against *B. abortus*-induced abortions. The small proportion of the population vaccinated and potentially re-vaccinated under Alternative A will result in indirect, short-term, beneficial, negligible impacts to bison population growth.

Cumulative Impacts

Past, present, and reasonably foreseeable actions occurring within the park and the surrounding area that would be expected to contribute to cumulative impacts include other capture facilities, hunting, quarantine efforts, winter use, road, construction, facility construction and increased visitation.

The State of Montana sporadically operates two capture facilities outside the west boundary of the park to manage the risk of brucellosis transmission to cattle in the Madison Valley. Bison outside the park may be captured and tested for brucellosis exposure, and calves and yearlings that test negative can be vaccinated and released. This state program is run similar to the program conducted at Stephens Creek by the NPS and, likewise, has only been sporadically implemented since 2000. Both vaccination strategies are directed by the IBMP and could benefit bison by directly reducing brucellosis infection and indirectly reducing transmission risk from bison to cattle. However, with vaccinations limited to capture facilities and on a sporadic basis, impacts would remain at the short-term or long-term, negligible level and would be unlikely to increase tolerance for untested bison outside Yellowstone National Park.

Livestock ranching occurs on lands surrounding the bison conservation area in the Madison and Yellowstone River Valleys. Ranching in these areas is primarily comprised of livestock and hay production operations. Livestock operators in the Montana portion of the GYE generally raise cow-calf pairs. Should any of these livestock populations become infected with brucellosis they could potentially sustain the infection and transmit it to subsequent generations. The proximity of livestock operations in the region results in moderate to major, negative impacts to expansion of the conservation area for wild bison.

Hunting in the park is not authorized by Congress and longstanding policy prohibits hunting in units of the NPS system unless specifically authorized by Congress (National Park Service Organic Act of 1916, 16 USC I, V § 26). However, the Montana Fish, Wildlife, and Parks and the Wyoming Game and Fish Department administer hunts of bison that migrate outside Yellowstone National Park during winter on some lands adjacent to the eastern and western boundaries of the park. In 2005, Montana Fish, Wildlife, and Parks established a 90-day bison hunt annually between November 15 and February 15 on lands adjacent to the park available for bison winter range (Montana Fish, Wildlife, and Parks and Department of Livestock 2004). The intent is to hunt wild, free-ranging bison under fair chase conditions and to reduce damage to private property by altering bison behavior and distribution. Also, in 2006, Montana recognized Salish-Kootenai and Nez-Perce treaty rights for bison harvest on unclaimed federal lands adjacent to the park. Since 2005, the Montana bison hunt and tribal treaty harvest have been successfully implemented with variable harvest levels depending on how many bison move outside the park in response to snow depth conditions in the higher mountains. Harvest has never exceeded 170 bison in any one year and demographic modeling suggests that the removal of 200-300 females per year would be necessary to maintain relatively stable population abundance (Hobbs et al. 2009). Thus, while hunting results in localized, adverse cumulative impacts, the level of impact is negligible.

Since 2005, the Montana bison hunt and tribal treaty harvest have been successfully implemented with variable harvest levels depending on how many bison move outside the park in response to snow depth conditions in the higher mountains.

The IBMP includes a quarantine protocol to provide flexibility in handling seronegative bison and in providing a source of live, disease-free bison for tribal governments and requesting organizations (USDI and USDA 2000a, b).

The IBMP includes a quarantine protocol to provide flexibility in handling seronegative bison and in providing a source of live, disease-free bison for tribal governments and requesting organizations (USDI and USDA

2000a, b). In 2005 and 2006, Montana Fish, Wildlife, and Parks and the Animal and Plant Health Inspection Service (2006) initiated a limited scope quarantine feasibility study with bison calves from Yellowstone National Park. Subsequently, these agencies established an Interagency/Tribal Bison Restoration Panel to identify suitable release sites for brucellosis-free bison resulting from the feasibility study, and solicited proposals from groups interested in restoring bison. Additional bison calves from Yellowstone National Park were delivered to the quarantine facility during 2008. Pursuant to the IBMP, the NPS may continue to provide bison calves for quarantine through its research permitting process, and participate on the Interagency/Tribal Bison Restoration Panel to select the most suitable restoration sites for the eventual release of these animals. Also, the NPS will support and encourage interagency partners to complete a study of quarantine procedures, determine the feasibility of certifying some seronegative bison as disease-free, and make them available for consignment/shipment to associated and bison-interested tribes. The NPS will continue to involve tribes in communications and meetings regarding the progress of the quarantine study and seek their input. Since quarantine is a management tool to handle surplus bison, there are no expected negative cumulative impacts. There would be expected beneficial impacts that cumulatively would become moderate to major in scope depending on how long the sources for translocation last. The beneficial impacts are due to creating a source of live bison to assist conservation of the species and to reduce the social conflict over killing Yellowstone bison that are not brucellosis infected.

The National Park Service currently operates under an Interim Winter Use Plan and Environmental Assessment for snowmobile and snow coach use in Yellowstone National Park. The interim plan and rule govern winter use in Yellowstone for two winters. A maximum of 318 best available technology, commercially guided snowmobiles are allowed each day along with up to 78 commercially guided snow coaches. The effects of road grooming (i.e., packing snow-covered roads to facilitate this over-snow vehicle recreation) on bison distribution and movements in Yellowstone National Park have been intensely debated each winter since the 1970s. Meagher (1993, 1998) reported increased numbers of bison, coupled with cascading increases in distribution during 1983-1995, based on aerial survey data, observed trails, and ground observations. NPS staffs are not aware of any scientific authority that has reviewed or analyzed these data independently that does not concur with these findings. However, there is no consensus on the mechanism(s) that caused these changes in bison demography and spatial dynamics. Meagher (1993, 1998) proposed that groomed roads were the fundamental mechanism enabling these changes, with energy saved by bison traveling on packed snow, in combination with better access to foraging habitat, resulting in enhanced population growth and increased movements to boundary areas. Thus, she recommended prohibiting road grooming to reduce the number and rate of bison leaving the park and induce them to revert to their traditional (i.e., pre-road grooming) distributions (Meagher 2003).

While the coincidence of range expansion by bison with road grooming is suggestive, it does not represent a finding of fact (Taper et al. 2000). Rather, the best available scientific findings suggest that (1) observed changes in bison distribution were likely consequences of natural population growth and range expansion that would have occurred with or without snow-packed roads (Bjornlie and Garrott 2001, Coughenour 2005, Gates et al. 2005), (2) road grooming did not change the population growth rates of bison relative to what may have been realized in the absence of road grooming (Gates et al. 2005, Bruggeman et al. 2006, Fuller 2006, Wagner 2006), (3) bison do not preferentially use groomed roads (Bjornlie and Garrott 2001, Bruggeman et al. 2006, 2009a), (4) road segments used by bison for travel corridors appear to be overlaid on what were likely natural travel pathways (Bjornlie and Garrott 2001, Bruggeman et al. 2007, 2009b), (5) bison use of travel corridors that include certain road segments would likely persist whether or not roads were groomed (Gates et al. 2005, Bruggeman 2006), and (6) bison behaviorally respond to snowmobiles, snow coaches, and associated human activities, but human disturbance is not a primary factor influencing their distribution (Borkowski et al. 2006, White et al. 2009). Given these conclusions, winter recreation could contribute to adverse cumulative impacts at the short and long term, localized, negligible level.

Other previously described park-level actions include road, bridge and facility construction; plus increased population and visitation that may be focused on wildlife viewing or photography. Road, bridge or facility construction should also have short term, localized, negligible impacts such as behavioral response during the construction phase, but long term impacts should not occur since new traffic corridors or facility sites will not be built. Increased visitation and subsequent increases in wildlife observation and photography will not change due to vaccination efforts at capture facilities, but these actions in themselves may cause behavioral response at the short term, localized, negligible level.

Conclusions

Under Alternative A (No Action), direct and indirect, short-term, adverse, localized minor impacts from injuries in capture facilities would result. Direct, short-term, adverse, minor impacts from tissue trauma due to hand vaccination could result, as well as indirect, short-term, adverse, negligible impacts due to possible infection, increased predation, or injury from other bison. Implementation of Alternative A would result in direct, short-term, beneficial, minor impacts in reducing the amount of *B. abortus* shed on the landscape. Indirect, short-term, beneficial, minor impacts on reducing the risk of *B. abortus* shed within specific management zones would be localized as a result of the small proportion of bison that are vaccine protected. Indirect, short-term, beneficial, minor impacts to the population's calving rate are expected to result from vaccine protection against *B. abortus*-induced abortions. The small proportion of the population vaccinated and potentially re-vaccinated under Alternative A will result in indirect, short-term, beneficial, negligible impacts to bison population growth.

Indirect, long-term, beneficial impacts on the duration of vaccine protection would be minor. Long-term impacts to management operations would be minor to moderate in scope as a result of reduced risk of transmission. Likewise, indirect, beneficial, minor impacts influencing the risk of brucellosis transmission to other bison and cattle in these localized management zones would result in the short-term. As a result, direct long-term, beneficial, moderate impacts to the bison population are expected to result from a reduction in the prevalence of brucellosis in the bison population, with fewer infections, abortions ,and shedding.

The cumulative impacts from implementing Alternative A would be adverse, localized, and negligible regarding disturbances to individual animals involved in capture, testing, and vaccination near the park boundary. The cumulative impacts to the population from reducing the brucellosis prevalence would be beneficial, localized, and negligible over the short-term, but minor over the long-term. The

In summary, the cumulative impacts from implementing Alternative A would be adverse, localized, and negligible regarding disturbances to individual animals involved in capture, testing, and vaccination near the park boundary. The cumulative impacts to the population from reducing the brucellosis prevalence would be beneficial, localized, and negligible over the short-term, but minor over the long-term.

cumulative impacts to the population from other past, present and reasonably foreseeable future actions should be adverse, localized and negligible.

> Remote delivery systems are inherently complex and logistical and mechanical failures are inevitable.

There would be no major adverse impacts to the Yellowstone bison population whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation of Yellowstone National Park, (2) key to the natural and cultural integrity of the park, and (3) identified as a goal in relevant, long-term NPS planning documents. Consequently, there would be no unacceptable impacts or impairment of the park's bison population as a result of implementing Alternative A.

4.6.1.2 Impacts from Alternative B (Remote-Delivery Vaccination—Young Bison Only)

Impacts of Alternative B include all of the impacts described for Alternative A and those associated with remote vaccination as described for this alternative. Remote delivery systems are inherently complex and logistical and mechanical failures are inevitable (Kreeger 1997). Remote vaccine delivery causes a greater level of tissue damage and a higher probability of some bleeding at the injection site than syringe delivery due to differences in diameter of the delivery tools and location of delivery within muscle tissue. While wounds resulting from remote delivery methods have the potential to become infected, Morgan et al. (2004) reported no evidence of tissue damage beyond 20 days post-vaccination with bio-degradable projectiles and concluded that the injection site was completely healed by that time. DeNicola et al. (1996) noted little tissue damage and minimal intramuscular hemorrhaging in white-tailed deer, while the outer casing of the projectile was almost completely dissolved within one hour of delivery. Laboratory hydration studies suggest that Strain RB51 vaccine in hydrogels will completely dissolve within one week (Christie et al. 2006). Herriges et al. (1989) reported a maximum of 0.2% mortality in elk remotely vaccinated on feed grounds in Wyoming. Under field conditions in Yellowstone National Park, rifle accuracy is expected to be lower than reported in controlled experiments (Roffe et al. 2002, Blanton et al. 2005). Wind, even at low velocity, can cause trajectories to miss the expected target unless the shooter can accurately adjust the point of aim. Also, bison will likely move during some shots as they maintain vigilance for predators, respond to the behavior of other bison in the group, and react to other stimuli.

> Penetration of the skin is essential for the biobullet to function. Some biobullets will likely fail to penetrate the skin of bison due to deflections and shattering of the projectile on impact with the animal.

Penetration of the skin is essential for the biobullet to function. Angus (1989) estimated that 30% of the animals in his study of ballistically vaccinated cattle failed to respond on serology tests because the implant did not penetrate the skin. Thus, some biobullets will likely fail to penetrate the skin of bison due to deflections and shattering of the projectile on impact with the animal (Kreeger 1997, Quist and Nettles 2003). Studies indicate that projectiles successfully breaking the skin will generally lodge at a depth varying from 2 to 8 centimeters due to skin thickness, muscle density, and the amount of connective tissue the bullet passes through (DeNicola et al. 1996, Quist and Nettles 2003). Quist and Nettles (2003) reported that 7% of remotely delivered placebo vaccines generated visible signs of bleeding in young bison, only one of which was quite noticeable. Thus, few animals are expected to exhibit visible signs of bleeding or other injuries that cause abnormal behavior. However, relatively few necropsies have been conducted to evaluate potential injuries caused by biobullet projectiles, and some proportion of the animals will likely succumb to injury due to a variety of uncontrollable features (e.g., the projectile severing a sensitive nerve embedded within the muscle mass of the target). Therefore, direct, short-term, adverse, negligible to minor impacts from muscle tissue trauma resulting from remote vaccinations are expected. Also, while vaccinated young bison with biobullet related injuries may be at a higher risk of predation and aggressive interactions with fellow herd members, these impacts are expected to be short-term and not create an unacceptable risk of mortality. Therefore, indirect, short-term, adverse impacts such as infection, risk of predation, and injury inflicted by other herd members are expected to be negligible to minor in the population.

Since the focus of vaccination effort is on reproductively immature animals, there would be no short-term impacts resulting in vaccine-induced abortions and subsequent transmission risk to susceptible individuals.

Since the focus of vaccination effort is on reproductively immature animals, there would be no short-term impacts resulting in vaccine-induced abortions and subsequent transmission risk to susceptible individuals. Thus, these impacts would be similar to those disclosed for Alternative A. Alternative B presents a higher probability that bison vaccinated as calves would receive a second vaccination as yearlings, however the potential for revaccinating young animals may not offer much benefit in extending the duration of vaccine protection. Alternative B does not provide an opportunity to vaccinate bison as adults and is not expected to provide long-term protection. Therefore, indirect, long-term, beneficial, minor impacts are expected regarding protection against brucellosis infection. The impacts are expected to be minor because bison calves only have the opportunity to be revaccinated again the following year as yearlings. Consequently, the duration of immunity may not last the remainder of an individual's life. No impacts to vaccine-induced transmission are expected to result because the vaccination targets are in non-reproducing age classes and would not be pregnant when vaccinated.

The addition of remote vaccination of calves and yearlings proposed in Alternative B results in only a minor difference (less than 10%) in seroprevalence decrease compared to Alternative A.

Since the remote vaccination component of Alternative B allows for more bison to be vaccinated, the anticipated decrease in infected bison further reduces the amount of bacteria that is shed on the landscape.

Model simulations suggest Alternative B would result in an increase in the number of vaccinated bison from approximately 0 (due to the sporadic implementation of hand vaccination during capture operations at the park boundary) to about 10% over a 30-year period (Figure 9). This would be approximately 10 times the level estimated for Alternative A. A higher proportion of vaccinated bison would lead to greater overall protection of the population from brucellosis infection than Alternative A. Model simulations estimated a decrease in seroprevalence from the initial state of about 47% to about 28% (i.e., a 40% decrease [(1 – 28/47)*100]) over a 30-year period, versus 35% for Alternative A (Figure 10).

The addition of remote vaccination of calves and yearlings results in only a minor difference (less than 10%) in seroprevalence decrease compared to Alternative A (Table 8). Brucellosis transmission occurs primarily during the later stages of pregnancy in infected bison. The amount of *B. abortus* shed on the landscape is related to the sum of *Brucella*-induced abortions and infectious live births. Since the remote vaccination component of Alternative B allows for more bison to be vaccinated, the anticipated decrease in infected bison further reduces the amount of bacteria that is shed on the landscape. A decrease in the number of infectious shedding events may have a positive effect on population growth and calving rates (Fuller et al. 2007b, Geremia et al. 2009). Therefore, direct, short-term, beneficial, moderate impacts are expected.

The general reaction of deer, elk, and bison to biobullet remote delivery includes kicking the leg injected by remote delivery projectile, turning the head to observe the injection site, or displaying no reaction.

The success of a remote vaccination program will depend on consistent and effective vaccine delivery over a long time period.

Young bison remotely vaccinated are likely to exhibit a more adverse reaction to remote delivery methods than older animals. However, young bison are not the group leaders and it is unlikely that their reactions would cause the entire group to move away from field delivery crews. Park staff is proficient at approaching bison groups in a manner that minimizes flight behavior by the bison (Clarke et al. 2005). However, it is unknown precisely how bison will react to being struck by a remotely delivered bio-absorbable projectile. The general reaction of deer, elk, and bison to biobullet remote delivery includes kicking the leg injected by remote delivery projectile, turning the head to observe the injection site, or displaying no reaction (Quist and Nettles 2003, Kesler et al. 1997, Thorne 1985). In some cases, animals take a few steps forward and, in rare instances, individuals trot off 40 meters or so. Bison react to dart delivery of immobilization chemicals in a similar way. Park staff conducted over 100 field immobilizations of bison and reactions to immobilizing darts are generally mild. Based on these observations, bison reactions to remote vaccinations should initially be relatively calm. However, the success of a remote vaccination program will depend on consistent and effective vaccine delivery over a long time period. The level of tolerance bison will have for vaccination crews as the program progresses is uncertain. Field vaccination may become more difficult if bison do not allow field crews to get within effective range for remote vaccination delivery. The consistent pressure of being vaccinated by field crews may result in bison being difficult to approach and, consequently, lead to a reduced efficiency in delivering vaccine to target individuals. Therefore, remote vaccination via biobullet delivery has the potential to alter bison behavior in a way that could lead to the avoidance of people. There is no information on how bison will react to being vaccinated with this remote method. Therefore, minor, indirect, adverse, long-term impacts influencing bison tolerance for people may result from consistent remote vaccination pressure.

Remote vaccination via biobullet delivery has the potential to alter bison behavior in a way that could lead to the avoidance of people. There is no information on how bison will react to being vaccinated with this remote method.

Alternative B does not provide an opportunity to vaccinate bison as adults and is not expected to provide long-term protection. The duration of immunity may not last the remainder of an individual’s life.

Concerns over the risk of brucellosis transmission from bison to cattle have driven the need for expanding a vaccination program for bison in Yellowstone National Park. The reduction of *B. abortus* shedding by bison under Alternative B as compared to Alternative A is a result of increasing the proportion of bison that are vaccine protected (Figure 9). More management options are available when there is a higher proportion of bison that are vaccine protected and fewer seropositive bison are removed during boundary management operations. Model simulations suggest that Alternative B would reduce seroprevalence by about 40% over a 30-year period, compared to a reduction of about 25% in Alternative A (Table 8). Consequently, Alternative B would result in fewer seropositive bison removed during boundary management operations than Alternative A which translates to the direct, long-term, beneficial moderate impacts of fewer seropositive bison shipped to slaughter.

> Alternative B model simulations estimated a 39% decrease in the number of seropositive bison removed during boundary management operations.

Cumulative Impacts
Anticipated cumulative impacts were described in Alternative A with the addition of the following: The increase in number of bison vaccinated under Alternative B would result in greater beneficial impacts to the population from reducing brucellosis prevalence. These localized benefits would be minor in the short-term and moderate over the long-term. Because remote vaccination methods have the potential to alter bison behavior, but only during the time of delivery, this could lead to some adverse cumulative impacts in relation to bison movement and wildlife viewing at a short term, localized, minor level. Given that all past, present and reasonably foreseeable future actions would be the same as Alternative A, the additional increase in number of bison vaccinated under Alternative B will increase beneficial cumulative impacts when combined with other efforts to reduce brucellosis prevalence and in turn increase tolerance to untested bison outside of Yellowstone required under the IBMP.

Conclusions
Because Alternative B combines the test, remove, and vaccinate strategy of Alternative A with remote vaccination, moderate, direct, short-term and long-term, beneficial decreases in population seroprevalence should occur. This moderate decrease in disease prevalence is anticipated to result in a corresponding level of protection against *B. abortus* infection in the bison population. Indirect, short-term, beneficial, population-wide, minor impacts to population calving rates are anticipated from vaccine protection against *B. abortus*-induced abortions. As a result of improved calving rates, minor, indirect, long-term, beneficial impacts are expected to increase bison population growth (Fuller et al. 2007b). Direct, short-term, beneficial, moderate impacts to the reduction of infectious birth material shed on the landscape will result from the greater number of bison vaccinated (Figure 9). Minor, indirect, adverse, long-term impacts influencing bison tolerance for people may result from consistent remote vaccination pressure.

By including remote vaccination of calves and yearlings, an indirect, long-term, beneficial impact moderately affecting the reduction in the risk of brucellosis transmission to other bison and to cattle is expected. With less transmission occurring, fewer bison are expected to react positively to serologic tests. As a result, direct long-term, beneficial, moderate impacts to the bison population are expected to result from a reduction in seropositive bison that are shipped to slaughter. This would increase management options available for decision makers. The additional increase in number of bison vaccinated under Alternative B combined with other efforts to reduce brucellosis prevalence will increase beneficial cumulative impacts and in turn increase tolerance to untested bison outside of Yellowstone required under the IBMP. These benefits would be minor in the short term and moderate in the long term.

There would be no major adverse impacts to the Yellowstone bison population whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation of Yellowstone National Park, (2) key to the natural and cultural integrity of the park, and (3) identified as a goal in relevant long term NPS planning documents. Consequently, there would be no unacceptable impacts or impairment of the park's bison population as a result of implementing Alternative B.

> Herriges et al. (1989) reported a maximum of 0.2% mortality in elk remotely vaccinated on feed grounds in Wyoming. Adult bison are expected to have a well developed immune system that can respond to potential infection resulting from remote delivery. They are also less likely to show visible signs of injury that may result in being selected by predators.
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> The expanded target class of bison eligible for remote vaccination in Alternative C results in a higher probability of bison receiving multiple vaccinations through their lives; thereby extending the duration of vaccine protection.
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> The initial conclusions are that vaccination of pregnant bison appears safe if conducted during the first half of gestation, and becomes even safer if individuals were initially vaccinated as calves or yearlings.

4.6.1.3 Impacts from Alternative C (Remote-Delivery Vaccination—Young Bison and Adult Females)

Impacts of Alternative C include all of the impacts described for Alternatives A and B, as well as those associated with remote vaccination of adult females as described for this alternative. Impacts to individual bison regarding tissue damage and injury would be similar to those described for Alternative B. Adult bison are expected to have a well developed immune system that can respond to potential infection resulting from remote delivery. They are also less likely to show visible signs of injury that may result in being selected by predators. In addition, older bison are less likely to be subordinates and, therefore, not prone to receiving aggressive treatments from other herd members. Therefore, indirect, short-term, adverse impacts such as infection, risk of predation, and injury inflicted by other herd members are expected to be negligible to minor in the population for calves or adult females.

Young bison remotely vaccinated are likely to exhibit a more adverse reaction to remote delivery methods than older animals. However, young bison are not the group leaders and it is unlikely that their reactions would cause the entire group to move away from field delivery crews. Increasing the number of individuals targeted for vaccination to include adult bison causes concern about how long each group of bison may tolerate remote vaccination operations. Having two distinct vaccination periods reduces the need to vaccinate a high percentage of a single group. Adult bison have shown mild initial reactions to being struck with immobilizing darts. Thus, similar reactions to remote vaccine delivery are expected.

The expanded target class of bison eligible for remote vaccination in Alternative C results in a higher probability of bison receiving multiple vaccinations through their lives; thereby extending the duration of vaccine protection. The risk of SRB51 when given to pregnant, adult females has been addressed in experimental studies, though the results are somewhat contradictory regarding the potential for vaccine-induced abortions. Palmer et al. (1996) noted that 25% of eight pregnant females aborted their fetus following vaccination. The individuals that aborted were vaccinated during the second half of gestation (4.5 and 6.5 months following conception). Elzer et al. (1998) reported no abortions when pregnant female bison were vaccinated during the first one-third of the gestation period (approximately two months following conception). These authors further reported that no abortions resulted in 29 adult female bison vaccinated during both their first and their second pregnancies (Davis and Elzer 2002). Olsen and Holland (2003) found that no vaccinated pregnant females aborted their pregnancies when these individuals were vaccinated during the second trimester of pregnancy (third to fifth month following conception). However, all of these bison were initially vaccinated as yearlings and then re-vaccinated again during their first pregnancy. In total, these three studies suggest that the vaccination of pregnant bison is low risk if conducted during the first half of gestation. The risk is even lower if individuals were initially vaccinated as calves or yearlings and the vaccination during pregnancy is actually a revaccination action. Therefore, the impacts on adult pregnant bison from remote vaccination would be short-term, adverse and negligible to minor; outweighed by the major, indirect, long-term beneficial impacts achieved through extended duration of immunity.

The additional remote vaccination of adult females should result in a significantly larger reduction in seroprevalence decrease (30 to 37% greater) compared to the other alternatives. The decrease in infectious events is greater for Alternative C than for either Alternative A or B at all time periods.

Model simulations estimate the number of vaccinated bison in the population under Alternative C should increase from 0 to about 29% over a 30-year period (Figure 9). All three of the proposed alternatives are expected to reduce brucellosis seroprevalence in Yellowstone bison, but the rate of decrease under each alternative is expected to vary (Figure 10). Model simulations of the impacts of Alternative C estimate a potential decrease in seroprevalence from about 47% to about 16% (i.e., a 66% decrease [(1 – 16/47)*100]) over a 30-year period. The inclusion of remotely vaccinated adult females should result in a significantly larger reduction in seroprevalence (about 30 to 37% greater) compared to the other alternatives (Table 8). Bison infected with brucellosis are expected to abort their first pregnancy subsequent to infection. The vaccine SRB51 has been demonstrated to offer protection from shedding *B. abortus* in pregnant bison (Olsen et al. 2003). This shedding occurs during a brucellosis-induced abortion or infectious live birth where the placenta and birth fluids are infected. The amount of *B. abortus* shed onto the landscape in a given year is the sum of these infectious events. The added protection from abortions due to increasing the number of vaccinates is expected to result in an increase in bison calving rates. The increase in bison calving rates may be a minor, indirect, beneficial impact having long-term effects on the population. The decrease in infectious events should be greater for Alternative C than for either Alternative A or B at all time periods; direct, long-term, beneficial, major impacts are expected due to a reduction in infections events.

Because Alternative C maximizes the number of bison that are vaccine protected, it results in the lowest potential for bison transmitting brucellosis to cattle outside the park. This result is due to the reduction in infectious events resulting from the high proportion of bison that have been vaccinated (Figure 9). The intensive remote vaccination effort further reduces the

Because Alternative C maximizes the number of bison that are vaccine protected, it results in the lowest potential for bison transmitting brucellosis to cattle outside the park.

A measurable indicator of the success of remote vaccination will be the seroprevalence rate in the population.

risk of bison shedding of *B. abortus* in the special management zones. A measurable indicator of the success of remote vaccination will be the seroprevalence rate in the population.

Over the 30-year simulation period, Alternative C was estimated to reduce seroprevalence substantially more than Alternative A and Alternative B (Figure 10). Long-term vaccine protection leading to higher levels of herd immunity for the population is a major, beneficial, indirect impact resulting from the intensive vaccination effort. Direct, short-term beneficial, major impacts will result from both the greater proportion of bison protected by the vaccine and the duration of this protection (Figure 9).

Cumulative Impacts

Anticipated cumulative impacts were described in Alternative A. Because remote vaccination methods have the potential to alter bison behavior, but only during the time of delivery, this could lead to some adverse cumulative impacts in relation to bison movement and wildlife viewing at a short term, localized, minor level. Given that all past, present, and reasonably foreseeable future actions would be the same as Alternative A, the additional increase in number of bison vaccinated under Alternative C will increase beneficial cumulative impacts when combined with other efforts to reduce brucellosis prevalence and in turn increase tolerance to untested bison outside of Yellowstone required under the IBMP.

The increase in population growth expected under Alternative C results from a moderate short-term, but major long-term, decrease in population seroprevalence. This decrease in seroprevalence also increases the management options available when it becomes necessary to remove bison that move to low-elevation winter ranges outside Yellowstone National Park. Removal of bison without having to ship animals to slaughter becomes a more likely option and would be a major beneficial impact to individuals of the population and may be of benefit to bison conservation in other places outside the park.

> Alternative C simulations estimated a 71% decrease in the number of seropositive bison removed during boundary management operations in the future under this alternative. This reduction in the number of seropositive bison that are included in boundary removals is a major, direct long-term, beneficial impact to bison conservation because seronegative bison have more socially acceptable options available for managers (e.g., quarantine; relocation to release sites) than do seropositive bison (e.g., slaughter, terminal quarantine).

Conclusions

Under Alternative C, the expanded target class of all female bison provides an opportunity for bison to be more effectively revaccinated throughout their lives. Thus, major, indirect, long-term, beneficial impacts on duration of immunity would occur.

Alternative C maximizes remote vaccination efforts and results in considerably more vaccinated animals than the other two alternatives. Direct, short term, adverse impacts from muscle trauma and indirect, short term, adverse impacts due to infection from this trauma could result. But direct, long-term, beneficial, major impacts affecting protection from brucellosis infection will also result. In turn, this reduction will have direct, long-term, beneficial, major impacts on the decrease in population seroprevalence. Repeated vaccination of individual bison when they are young and as adults could lead to long-term vaccine protection and higher levels of herd immunity for the population, resulting in a major, beneficial, indirect impact resulting from the intensive vaccination effort. Direct, short-term beneficial, major impacts to the reduction of infectious birth material shed on the landscape will result from both the greater proportion of bison protected by the vaccine and the duration of this protection (Figure 9). The increase in bison calving rates may be a minor, indirect, beneficial impact having long-term effects on the population.

The potential direct, short-term, adverse impacts regarding vaccine-induced abortion are expected to be negligible to minor. The indirect, adverse impacts influencing bison tolerance for people are expected to be minor in the short-term. The overall impacts on bison behavior are expected to be similar to that of Alternative B.

A major, indirect, long-term, beneficial impact on the reduction in the risk of brucellosis transmission to other bison is expected to result from Alternative C. The reduction in the number of seropositive bison that are included in boundary removals is a major, direct, long-term, beneficial impact to bison conservation because seronegative bison have more socially acceptable options available for managers (e.g., quarantine; relocation to release sites) than do seropositive bison (e.g., slaughter, terminal quarantine).

Because remote vaccination methods have the potential to alter bison behavior, but only during the time of delivery, this could lead to some adverse cumulative impacts in relation to bison movement and wildlife viewing at a short term, localized, minor level. But, the additional increase in number of bison vaccinated under Alternative C combined with other efforts to reduce brucellosis prevalence will increase beneficial cumulative impacts and in turn increase tolerance to untested bison outside of Yellowstone required under the IBMP. These cumulative beneficial impacts would be moderate in the short term and major in the long term.

There would be no major adverse impacts to the Yellowstone bison population whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation of Yellowstone National Park, (2) key to the natural and cultural integrity of the park, and (3) identified as a goal in relevant long-term NPS planning documents. Consequently, there would be no unacceptable impacts or impairment of the park’s bison population as a result of implementing Alternative C.

4.6.2 Other Wildlife, Including Threatened Species

To determine impacts to other wildlife species, NPS staff first identified species that might occupy areas of possible bison vaccination activities. These species have the potential to be directly impacted, while indirect impact is possible for other species not occupying these areas. Potential impacts were then analyzed based on information obtained from literature review, consultation with park staff who track wildlife populations, and consultation with cooperating state and federal agencies implementing the IBMP. The geographic area of analysis for other wildlife included habitats within and near Yellowstone National Park. The effects of vaccinating bison on other wildlife species include displacing individual animals, disturbing their activities as NPS staff travel the landscape to conduct vaccination operations, and the physical effects to individual animals that may be inadvertently exposed to vaccine dispersed during field operations. No modifications to wildlife habitats are proposed, so impacts of this nature were not analyzed. The thresholds of intensity used to describe the impacts of the proposed actions are as follows:

- *Negligible*—there would be no observable or measurable impacts to native species, their habitats, or the natural processes sustaining them. Impacts would be well within natural fluctuations.

> Carcasses of vaccinates would be less likely to be transmission vectors than carcasses of field strain infected bison. The impacts to a variety of species from exposure to vaccine SRB51 have been evaluated and found to create no clinical or population level mortality (Cook and Rhyan 2002; Table 10).

- *Minor*—impacts would be detectable, but would not be outside the natural range of variability. Small changes to population numbers, population structure, genetic variability (determined through study of DNA markers), and other demographic factors might occur. Occasional responses to disturbance by some individuals could be expected, but without interference to feeding, reproduction, or other factors affecting population levels. Impacts would be outside critical reproduction periods for sensitive native species.
- *Moderate*—impacts on native species, their habitats, or the natural processes sustaining them would be detectable and could be outside the natural range of variability. Changes to population numbers, population structure, genetic variability, and other demographic factors would occur, but species would remain stable and viable. Frequent responses to disturbance by some individuals could be expected, with some negative impacts to feeding, reproduction, or other factors affecting population level parameters. Some impacts might occur during critical periods of reproduction or in key habitat.
- *Major*—impacts on native species, their habitats, or the natural processes sustaining them would be detectable, outside the natural range of variability, and permanent. Population numbers, population structure, genetic variability, and other demographic factors might experience large decreases. Frequent responses to disturbance by some individuals would be expected, with negative impacts to feeding, reproduction, or other factors resulting in a decrease in population levels.

Individual animals may change their behavior (e.g., feeding, resting, traveling) in response to seeing and/or hearing humans in their habitat (Knight and Cole 1991, Knight and Gutzwiller 1995). However, individuals and species vary in their sensitivity to human disturbance (Boyle and Sampson 1985). Individual animals found in close proximity to road corridors and developments would be considered more tolerant of human encounters than those found in habitats further removed from human activities (Rutberg 1997, Thompson and Henderson 1998).

Vaccinated bison should mount a milder immune response to a pathogen than the responses observed in infected, naive individuals (Tizard 2004, Black 2005). Olsen et al. (1998, 1999) noted that bison will clear their system of vaccine SRB51 by 24 weeks after vaccination. The probability of remotely vaccinated bison dying within 24 weeks of becoming vaccinated is small. Therefore, carcasses of vaccinates would be less likely to be sources of infection than carcasses of field strain infected bison. There may be indirect impacts to other wildlife species that would occur from exposure to bacteria consumed during the act of preying or scavenging on a vaccinated bison. The impacts to a variety of species from exposure to vaccine SRB51 have been evaluated and found to create no clinical or population level mortality (Cook and Rhyan 2002; Table 9).

Table 9. Non-target species exposed to strain RB51 to evaluate bio-safety effects

Ninety deer mice were orally exposed or intraperitoneally injected with SRB51.	Cook et al. (2001)
Twenty-one ground squirrels, 21 deer mice, 21 prairie voles, and 13 ravens were orally exposed to SRB51.	Januszewski et al. (2001)
Twenty-four coyotes, 10 moose, 10 bighorn sheep, 11 mule deer, and nine pronghorn were orally exposed to SRB51.	Kreeger et al. (2002)
Black bears were orally exposed to SRB51.	Olsen et al. (2004)
Nineteen coyotes were orally exposed to SRB51. This study also looked at the bio-safety of coyotes exposed to Strain 19.	Davis et al. (2000)
Thirty pronghorn were orally exposed to SRB51. This study also looked at the bio-safety of pronghorn exposed to Strain 19.	Elzer et al. (2000)

A separate biological assessment describing the impacts likely to affect listed species was prepared for the USFWS (Jones et al. 2006). Section 7 consultation was completed with a concurrence letter provided to the park in January 2007 (Appendix K).

4.6.2.1 Impacts from Alternative A (No Action—Boundary Capture Pen Vaccination of Calves and Yearlings)

There are very few direct effects to other wildlife species from vaccinating bison in the Stephens Creek corral. Mule deer, elk, and pronghorn regularly travel past the corral area during time periods when capture and testing operations are being conducted. These species can be observed moving away from field operations that round up bison and push them in to the holding pens. This type of disturbance to individual animals or groups could create a short term increase in stress hormones that quickly disappears as they move away from the bison management operations. Additional short term effects could occur from the increased traffic along the roadway into the corral area due to displacement of these species away from the road. These types of direct, adverse impacts are short-term and localized because Yellowstone National Park has only one location where bison are captured. Direct impacts to federally listed species (Canada lynx, gray wolves, grizzly bears) are not expected because (1) vaccination of bison is unlikely to occur in lynx habitat or near wolf dens, (2) vaccination activities would likely result in only localized displacement of individual wolves, and (3) there should be no associated injury or mortality to lynx or wolves that consume carrion from bison vaccinated with SRB51 (Appendix K).

Indirect impacts from vaccinated bison that are released from the holding facility and subsequently die within 24 weeks of vaccination are expected if those vaccinates still have vaccine strain *B. abortus* in their system. These individuals while few in number, would become possible vectors of exposure should predators or scavengers feed on the carcass before it becomes rotten. *Brucella abortus* has been isolated from wild carnivores (including grizzly bears, black bears, wolves, coyotes, and foxes) in areas where infected bison and elk are found (Tessaro 1986). Those predators consume infected elk and bison meat and subsequently mount natural immune responses to this type of natural exposure. Carnivores may contribute to disease transmission by transporting infectious materials from one site to another, spreading bacteria across the landscape. However, predation and scavenging by carnivores also likely decontaminates the local environment of infectious *B. abortus* because the concentration of bacteria would become diluted in the ecosystem and exhibit a greater probability of exposure to ultraviolet light which is a natural killer of bacteria (Cheville et al. 1998). *Brucella abortus* bacteria die quickly in the local environment when exposed to ultraviolet light and warmer temperatures of spring time (Cook 1999, Aune et al. 2007). Some ungulates such as mule deer, white-tailed deer, and pronghorn have never been documented to harbor *B. abortus*. Four cases of brucellosis in wild moose were reported between 1937 and 1985 (Cheville et al. 1998). Thus, it is possible, but highly unlikely, that bacteria from vaccinated bison could be transmitted to other ungulates. Therefore, current transmission rates of *B. abortus* under Alternative A would have a long-term, indirect, park-wide, negligible to minor adverse impacts on any predators or scavengers, including the gray wolf, grizzly bear, and bald eagle as well as ungulates. Due to the Canada lynx's preference for thick forest, they would not be expected to encounter bison carcasses on the landscape.

Cumulative Impacts

Past, present, and reasonably foreseeable actions occurring within the park and the surrounding area that would be expected to contribute to cumulative impacts to other wildlife include all those listed in the introductory sections earlier in this chapter. In summary, these activities can result in loss of habitat and disturbance to individuals. In addition, wildland fire is a natural process in this ecosystem and the wildlife species that occupy habitats here have evolved to coexist with fires. Fires curb the natural colonization of landscapes by forested plant communities and restore native grasses and wetland/riparian habitat. Wild fires and controlled burns occur on both public and private lands and create both short- and long-term adverse effects to some species by displacing them, while creating beneficial habitat changes for others.

> Carnivores may contribute to disease transmission by transporting infectious materials from one site to another, spreading bacteria across the landscape. However, predation and scavenging by carnivores also likely decontaminates the local environment because the concentration of bacteria would become diluted in the system and exhibit a greater probability of exposure to ultraviolet light which is a natural killer of bacteria (Cheville et al. 1998).
>
> Mule deer, white-tailed deer, and pronghorn have never been documented to harbor *B. abortus.*

While loss of habitat is occurring throughout the GYE, the primary impacts occurring from vaccination will be disturbance to wildlife species. While localized effects have likely created negligible to minor adverse impacts, regionalized impacts to small species have been moderate. Thus, the national parks and nearby wilderness areas have become more valuable to most wildlife species of the ecosystem because of the large expanse of pristine habitat. The GYE is renowned for its abundance of recreational opportunities. Human recreationists can create disturbances to wildlife that generally affect individuals or groups of individuals only. Across the GYE these disturbances can add up to moderate levels of disturbance for some species.

On private lands surrounding the park, agricultural operations, resorts, and nearby towns have resulted in the alteration of natural vegetation communities and processes. These types of habitat alterations have created moderate to major adverse impacts to the abundance of natural habitats for many wildlife species, while creating minor to moderate beneficial impacts to some species that are more tolerant of human activities (Fleischner 1994, Parmenter et al. 2003). Construction activities associated with park operations and developments create short-term, localized disturbances to animal behaviors and likely resulted in minor to moderate, adverse impacts on wildlife in localized areas. Increased human activity from visitation to Yellowstone National Park has also likely resulted in short-term, localized, minor to moderate, adverse impacts in the form of disturbances to individuals of many wildlife species. When combined with the highly localized action covered under Alternative A, adverse impacts would remain indirect, short-term and negligible.

Conclusions

Under Alternative A, the vaccination of bison helps prevent the already low probability of transmission of *B. abortus* from bison to other wildlife, including bald eagles, grizzly bears and gray wolves from occurring and represents a long-term, indirect, park-wide, negligible to minor, beneficial effect. Since vaccination actions occur so infrequently at the Stephens Creek facility (0 to 10 days per year), the short term, direct, adverse impacts that create disturbance to wildlife behaviors would be negligible. Long-term impacts are expected to benefit many wildlife species that may be indirectly affected by exposure to *B. abortus* bacteria because the cumulative effects of vaccinating bison would result in a gradual decrease in the exposure to the disease by other wildlife species. No impacts to Canada lynx are expected to result from disturbance by human activities or exposure to vaccine bacteria. In summary, there would be no major adverse impacts to other wildlife populations, including federally threatened species, whose conservation are (1) necessary to fulfill specific purposes identified in the establishing legislation of Yellowstone National Park, (2) key to the natural or cultural integrity of the park, or (3) identified as a goal in relevant long term NPS planning documents. Consequently, there would be no unacceptable impacts or impairment of the park's other wildlife resources or values as a result of implementing Alternative A.

Under Alternative A there would be no major adverse impacts to other wildlife populations, including federally threatened species.

4.6.2.2 Impacts from Alternative B (Remote-Delivery Vaccination—Young Bison Only)

The impacts to other wildlife species from implementation of Alternative B would include those described for Alternative A, but would be greater in effect from a regional perspective because the area of vaccine distribution would be increased to most of the bison habitat throughout Yellowstone National Park. The likelihood that park staff conducting vaccination operations would create short-term disturbances to individual animals and groups would increase in frequency as remote vaccination operations occurred over a time period up to six months. Over the long-term, expansion of the vaccination program under Alternative B would reduce the possibility of transmission of *B. abortus* from bison to other wildlife species by reducing the probability of bison shedding the bacteria. This would provide a minor, long-term, regional, beneficial impact for other wildlife species.

Impacts that would not occur under Alternative A, but are possible under Alternative B, include the possibility of inadvertent exposure to vaccine from doses that deflect from the intended target, lodge on the surface of the ground, and are eaten by non-target animals. Failure of the remote delivery projectile to penetrate the skin of the bison is a concern. While the amount of vaccine that would be left in the environment would be quite small per deflected dose, the exposure threat to other wildlife species from eating the projectile would most likely be of lower impact than that from an encounter with a vaccinated bison carcass. The adverse impacts of this type of failure would be short-term, local, and negligible as a result of the short-term viability of the bacteria and the low probability that any wildlife species would eat the projectile. Vaccine doses are expected to get lost in the vegetation and disintegrate in the environment. Field studies indicate that *B. abortus* persistence decreases rapidly with increased ultraviolet exposure, heat, and dry conditions (Cook et al. 2004, Aune et al. 2007). Thus, persistence of the vaccine would probably be limited to a few months or weeks depending on environmental conditions. The USFWS concurred with the NPS finding that impacts from this action may affect, but are not likely to adversely affect, bald eagles, Canada lynx, grizzly bears, and gray wolves in Yellowstone National Park.

The impacts to other wildlife species from implementation of Alternative B would include those described for Alternative A but be greater in effect from a regional perspective because the area of vaccine distribution would be increased to most of the bison habitat throughout Yellowstone National Park.

Impacts that would not occur under Alternative A, but are possible under Alternative B, include the possibility of inadvertent exposure to vaccine from doses that deflect from the intended target, lodge on the surface of the ground, and are eaten by non-target animals.

Cumulative Impacts

The cumulative impacts of implementing Alternative B on other wildlife species are similar to those described in Alternative A. The increased probability of encountering other wildlife and disturbing or displacing individuals of any species when conducting remote delivery operations is small and cumulatively would still result in localized, short-term impacts, but would increase the intensity of effect to result in minor to moderate impacts to other wildlife species. The impacts associated with exposure to vaccine by other wildlife species under Alternative B would increase over those expected under Alternative A. However, the effects to individual animals would still be considered minor because the literature describing experimental exposure to non-target wildlife overwhelmingly concluded that the vaccine does not create unacceptable clinical effects in those non-target species that were studied (Table 9). Overall, the cumulative impacts of past, present, and future projects on wildlife would be minor, localized, and adverse over the short term, and localized, minor, and adverse over the long term.

There would be no unacceptable impacts or impairment of the park's other wildlife resources or values as a result of implementing Alternative B.

Conclusions

The direct impacts of disturbance and indirect impacts of exposure to the vaccine would be adverse, localized where they occur, and short in duration. The intensity of impact would be minor in scope for the short-term. Over the long-term, an expansion of the bison vaccination program would reduce exposure to *B. abortus* bacteria in the ecosystem and provide a minor beneficial effect on other wildlife, including federally threatened species. The reduced probability of transmission of *B. abortus* from bison to other wildlife including bald eagles, grizzly bears, and gray wolves would represent a long-term, indirect, park-wide, minor, beneficial effect. Given these conclusions and the USFWS concurrence with the NPS finding, there would be no major adverse impacts to other wildlife populations whose conservation are (1) necessary to fulfill specific purposes identified in the establishing legislation of Yellowstone National Park, (2) key to the natural or cultural integrity of the park, or (3) identified as a goal in relevant long term NPS planning documents. Consequently, there would be no unacceptable impacts or impairment of the park's other wildlife resources or values as a result of implementing Alternative B.

4.6.2.3 Impacts from Alternative C (Remote-Delivery Vaccination—Young Bison and Adult Females)

The type of impacts to other wildlife species from implementation of Alternative C would be the same as those described for Alternative B. The direct impacts to other wildlife species that result in disturbance to individual animal behavior would be similar because park staff would follow the same encounter strategy in approaching groups of bison. Expanding the vaccination program, as described under this alternative, would result in a greater proportion of bison being vaccinated against brucellosis than described in either of the two previous alternatives and subsequently result in the threat of natural brucellosis exposure to other wildlife species decreasing at a greater rate than would occur under Alternatives A or B. Thus, a long-term, regional, minor to moderate, beneficial effect on all other wildlife species would be expected. The indirect impacts to other wildlife species from Alternative C would be exposure to the vaccine by encountering vaccine-infected bison that died, and by encountering (e.g., eating) missed doses of vaccine that were lost on the landscape. These impacts are expected to be short term and localized because encapsulated vaccine has a short life expectancy when exposed to ultraviolet light and heat. The USFWS concurred with the NPS finding that impacts from this action may affect, but are not likely to adversely affect, bald eagles, Canada lynx, grizzly bears, and gray wolves in Yellowstone National Park.

> The indirect impacts to other wildlife species from Alternative C would be exposure to the vaccine by encountering vaccine-infected bison that died, and by encountering (e.g., eating) missed doses of vaccine that were lost on the landscape.

Cumulative Impacts

The types of cumulative impacts to other wildlife species from implementing Alternative C are similar to those described in Alternative B. The impacts associated with disturbances to other wildlife species from encounters with park staff should be similar to Alternative B because the approach and encounter strategy would be the same; the only difference would be the targets selected within a group of bison. The impacts associated with exposure to vaccine by other wildlife species under Alternative C may increase over those expected under Alternative B, primarily due to the greater risk of aborting a pregnancy by vaccinating adult female bison. While the risk of exposure may be greater under Alternative C, the effects to individual animals would still be considered minor because the literature describing experimental exposure to non-target wildlife overwhelmingly concluded that the vaccine does not create unacceptable clinical effects in those non-target species that were studied (Table 9).

> There would be no impairment of the park's other wildlife resources or values as a result of implementing Alternative C.

Conclusions

The probability of individuals from other wildlife species becoming exposed to vaccine in the environment increases under this alternative in the short-term. However, the impacts remain localized where they occur and short in duration. The long-term decrease in brucellosis infection rate among bison would subsequently and systematically reduce the probability of exposure to other wildlife species in the future. The reduced probability of transmission of *B. abortus* from bison to other wildlife including bald eagles, grizzly bears, and gray wolves would represent a long-term, indirect, park-wide, minor, beneficial effect. Given these conclusions and the USFWS concurrence with the NPS finding, there would be no major adverse impacts to other wildlife populations or values whose conservation are (1) necessary to fulfill specific purposes identified in the establishing legislation of Yellowstone National Park, (2) key to the natural or cultural integrity of the park, or (3) identified as a goal in relevant long term NPS planning documents. Consequently, there would be no impairment of the park's other wildlife resources or values as a result of implementing Alternative C.

4.6.3 Ethnographic Resources

To analyze impacts on ethnographic resources, information was collected from the 26 tribes associated with Yellowstone National Park and the 54 bison-interested tribes through initial scoping and government-to-government consultation meetings with these tribes. Comments regarding bison, their treatment, and about vaccination were received from tribes in these venues. The geographic analysis for ethnographic resources includes the distribution of Yellowstone bison in and adjacent to the park.

The following thresholds of intensity were used to describe the impacts of the proposed actions on ethnographic resources:

- *Negligible*—the impact would be at the lowest level of detection with neither adverse nor beneficial consequences.
- *Minor*—adverse impacts would be slight, but noticeable. The impacts would not appreciably alter the resource conditions, or access to the resource by affiliated tribal members, or impair traditional practices and beliefs. Beneficial impacts to the resource would be measurable and localized. The resource would be maintained and preserved in its natural state, access to the resource would be temporarily or slightly enhanced, or the qualities of the resource considered to be culturally important might be slightly enhanced.
- *Moderate*—adverse impacts would be apparent and would alter resource conditions or interfere with access to the resource by affiliated tribal members. The relationship between the resource and the beliefs and practices of affiliated groups may be altered, even though the practices and beliefs would survive. Beneficial impacts would be measurable and contribute to the qualities of the resource, access to the resource by affiliated tribal members, and the relationship between the resource and the beliefs and practices of affiliated groups.
- *Major*—adverse impacts would alter the conditions of the resource that are considered important, impair access to the resource by affiliated tribal members, or substantially alter the relationship between the resource and the practices and beliefs of the affiliated groups to the extent that the survival of those practices and beliefs would be jeopardized. The impacts would result in significant deterioration or destabilization of the condition

or culturally valued elements of the resource. Beneficial impacts would be measurable and result in substantial improvement in the qualities of the resource, access to the resource by tribal members, or the relationship between the resource and the beliefs and practices of affiliated groups.

Some American Indian tribes would prefer to allow bison to roam outside the boundary of the park and heal themselves naturally. These tribes have said that vaccination programs will contaminate the spirit of the local bison.

Some American Indians have expressed that bison are being singled out and discriminated against because some individuals have brucellosis, while individuals of other wildlife species (e.g., elk) are also infected with brucellosis but not subjected to vaccination. Some believe that Yellowstone bison are being discriminated against in the same manner that American Indians were treated during the colonization of this country.

4.6.3.1 Impacts from Alternative A (No Action—Boundary Capture Pen Vaccination of Calves and Yearlings)

The impacts of vaccinating wild bison include intangible values that American Indian tribes hold regarding Yellowstone bison. These intangibles vary greatly between tribes and in some cases between members of the same tribe. Some American Indians have expressed that vaccinating bison is an unnecessary Anglo-American method for treating infected animals. Also, some American Indians would prefer to allow bison to roam outside the boundary of the park and heal themselves naturally by finding the right medicine in the plants of the earth. In addition, some American Indians believe that vaccination may contaminate bison for purposes of consuming the meat or using parts in their ceremonies. Furthermore, some American Indian tribes have expressed that vaccination programs will contaminate the spirit of the local bison.

Implementation of Alternative A causes some concern to tribal individuals and to some tribes in general. They have stated that bison are being singled out and discriminated against because some individuals have brucellosis, while individuals of other wildlife species (e.g., elk) are also infected with brucellosis but not subjected to vaccination or other management actions similar to Yellowstone bison. Thus, some American Indians have expressed that Yellowstone bison are being discriminated against in the same manner that American Indians were treated during the colonization of this country, which resulted in decimated, localized populations of American Indians. Some American Indians have said that what happens to bison will always remain an indicator of the treatment of American Indians. They also state that the capturing and vaccinating of bison causes undue stress to the animals. While it is difficult to quantify, tribal concerns point to the possibility that vaccination may alter or impair traditional practices and beliefs, because some tribes consider vaccination disrespectful treatment of bison. Also, tribal treaty harvests by the Salish-Kootenai and Nez-Perce on unclaimed federal lands adjacent to the park may be adversely affected to a minor extent if some members believe that vaccination contaminates bison for purposes of consuming the meat or using parts in their ceremonies. Therefore, impacts would be direct or indirect, localized, short-term or long-term, and adverse at minor to moderate levels.

Cumulative Impacts

Past, present, and reasonably foreseeable actions occurring within the park and the surrounding area that would be expected to contribute to cumulative impacts include all activities presented earlier in this chapter. The geographic scale is at a broader scale for this resource, though, due to the extent of tribal interest. Human colonization of the native range of American bison has reduced the number of free-ranging wild bison to a handful of populations where many millions of bison once roamed. The cumulative impacts of vaccinating the Yellowstone bison population does not add any further impacts that result in shrinking numbers or distribution of bison. The long term cumulative impacts from Alternative A would be minor to moderately adverse, and affect tribes throughout the region. However, long-term beneficial impacts may occur if the program is successful in decreasing the prevalence of the disease in the population. When considered at the population level, vaccination of bison would be a method that may eventually lower the prevalence of brucellosis and increase the probability that disease-free bison may be eligible for live transfer to tribes associated with Yellowstone National Park, as many tribes have requested.

> The long term cumulative impacts from Alternative A would be minor to moderately adverse, and affect tribes throughout the region because vaccination at the Stephens Creek facility would continue, which some tribes have expressed is disrespectful treatment of bison. However, long-term beneficial impacts may occur if the program is successful in decreasing the prevalence of the disease in the population.

Conclusions

Even though vaccination actions occur infrequently at the Stephens Creek facility (0 to 10 days per year), the direct impacts that create reduced value of Yellowstone bison by some tribal members are both short- and long-term, adverse, minor impacts to ethnographic resources regionally. The long term cumulative impacts from Alternative A would be minor to moderately adverse, and affect tribes throughout the region. Because there would be no major adverse impacts to resources or values whose conservation are (1) necessary to fulfill specific purposes identified in the establishing legislation of Yellowstone National Park, (2) key to the natural or cultural integrity of the park, or (3) identified as a goal in the park's General Management Plan or other relevant NPS planning document, there would be no impairment of the park's ethnographic resources or values under this alternative.

> For Alternative B there may be greater access to disease-free bison for American Indian Tribes because fewer seropositive individual bison would be sent to slaughter and, consequently, more seronegative bison would be eligible to enter quarantine and/or be relocated.

4.6.3.2 Impacts from Alternative B (Remote-Delivery Vaccination—Young Bison Only)

The impacts of Alternative B would be similar to those described for Alternative A (direct, short- and long-term, adverse, moderate impacts to ethnographic resources regionally), except that a larger proportion of bison would be vaccinated. There may be greater access to disease-free bison for American Indian tribes because fewer seropositive individual bison would be sent to slaughter and, consequently, more seronegative bison would be eligible to enter quarantine and/or be relocated. Long-term beneficial impacts may occur if vaccination of bison is successful at reducing the proportion of brucellosis-infected bison. These indirect effects would be realized by American Indian tribes if measures to certify seronegative bison as disease-free can be formalized and allow surplus Yellowstone bison to be consigned as live animals to bison-interested tribes.

Cumulative Impacts

Cumulative impacts to the bison under Alternative B, combined with other past, present, and reasonably foreseeable actions, would be the same as those under Alternative A, with an incremental increase in impacts due to vaccinating more bison.

Conclusions

While more bison would become vaccinated under Alternative B, the direct impacts that create reduced value of Yellowstone bison by some tribal members are both short- and long-term, adverse, moderate impacts to ethnographic resources regionally. Long-term beneficial impacts may occur if vaccination of bison is successful at reducing the proportion of brucellosis-infected bison. Cumulative impacts to the bison under Alternative B would be the same as those under Alternative A, with an incremental increase in beneficial impacts. Because there would be no major adverse impacts to resources or values whose conservation are (1) necessary to fulfill specific purposes identified in the establishing legislation of Yellowstone National Park, (2) key to the natural or cultural integrity of the park, or (3) identified as a goal in the park's General Management Plan or other relevant NPS planning document, there would be no impairment of the park's ethnographic resources or values under this alternative.

4.6.3.3 Impacts from Alternative C (Remote-Delivery Vaccination—Young Bison and Adult Females)

The impacts of Alternative C would be similar to those described for Alternatives A and B, except that a larger proportion of bison would be vaccinated. The direct impacts that affect values about Yellowstone bison by some tribal members would be both short- and long-term, beneficial, moderate impacts to ethnographic resources regionally. Long-term beneficial impacts may occur at a greater scale than Alternative B if vaccination of bison is successful at reducing the proportion of brucellosis-infected bison.

Cumulative Impacts

Cumulative impacts to Yellowstone bison under Alternative C would be the same as those under Alternatives A and B, with an incremental increase in impacts due to vaccinating more bison.

Conclusions

The direct impacts that affect values about Yellowstone bison by some tribal members are both short- and long-term, beneficial, moderate impacts to ethnographic resources regionally. Long-term beneficial impacts may occur at a greater scale if vaccination of bison is successful at reducing the proportion of brucellosis-infected bison. Cumulative impacts to Yellowstone bison under Alternative C would be the same as those under Alternatives A and B with an incremental increase in beneficial impacts over the long term. Because there would be no major adverse impacts to resources or values whose conservation are (1) necessary to fulfill specific purposes identified in the establishing legislation of Yellowstone National Park, (2) key to the natural or cultural integrity of the park, or (3) identified as a goal in the park's General Management Plan or other relevant NPS planning document, there would be no impairment of the park's ethnographic resources or values under this alternative.

4.6.4 Human Health and Safety

> Inadvertent exposures to *Brucella* sp. by humans can result in infection referred to as undulant fever. Undulant fever does not readily kill its victims, but the disease is serious enough to seek antibiotic treatment.

Impacts to human health and safety were assessed by determining the current conditions of human health and safety likely to be affected by the alternatives, and then by identifying the impacts vaccination programs implemented under each alternative would have on these conditions. The geographic area of analysis for human health and safety was limited to inside the park boundary where delivery would occur and laboratory situations where vaccine may be packaged for remote delivery. The NPS reviewed information about human brucellosis in the literature to qualitatively evaluate the risks to human health that might result from a vaccination program.

Effective public health measures now make human exposure to brucellosis a rare disease in industrialized countries (Young and Corbel 2000, Yagupsky and Baron 2005). However, inadvertent exposures to *Brucella* sp. by humans can result in infection referred to as undulant fever (Maloney 2008). Undulant fever does not commonly kill its victims, but the disease is serious enough to seek antibiotic treatment (Centers for Disease Control 2005). Infection generally occurs via occupational exposure. Occupations most at risk are cattlemen, slaughterhouse workers, veterinarians, and wildlife biologists. Hunters in areas of endemic brucellosis (i.e., GYE and southeastern United States) can be at higher risk if they are careless in field dressing their game. Nearly all patients respond to appropriate antibiotic therapy, with fewer than 10% relapsing. *Brucella* bacteria can gain entry into humans through breaks in the skin, mucous membranes, conjunctival membrane of the eye, and respiratory and intestinal tracts.

The thresholds of intensity used to describe the impacts of the proposed actions on human health and safety are as follows:

- *Negligible*—there would be no discernible effects to employee or visitor safety. Slight injuries could occur, but none would be reportable.
- *Minor*—any reported employee or visitor injury would require first aid that could be provided by park staff. Employee injuries would not involve lost work time.
- *Moderate*—any reported employee or visitor injury would require medical attention beyond what is available at the park. Employee injuries would result in lost work time.
- *Major*—an employee or visitor injury would result in permanent disability or death.

4.6.4.1 Impacts from Alternative A (No Action—Boundary Capture Pen Vaccination of Calves and Yearlings)

The direct impacts of implementing Alternative A are short term, adverse, minor to moderate (moderate if antibiotics are required) and localized at the Stephens Creek capture facility. These impacts would be accidental exposure of *B. abortus* vaccine to veterinarians and wildlife biologists implementing the program. The probability of accidental exposure by needle stick while transferring vaccine to syringes and inserting needles into bison physically immobilized in the squeeze chute is low (Cheville et al. 1998). Human infection may not be detectable for 1-8 weeks, the time period for incubation of the bacteria to manifest an infection (Maloney 2008).

An additional direct safety impact could be skin abrasions should an individual animal move about in the chute more quickly than staff could react and retract their hands.

Hunters should not consume the meat if a bison is killed within 21 days of being vaccinated. Thus, the National Park Service will continue to notify state wildlife agencies and tribes of forthcoming vaccination efforts through established working groups and communications networks.

The Food and Drug Administration has determined that drug or vaccine residues may remain in animal tissues, be consumed by humans, and result in an adverse reaction. Thus, they have established "withdrawal times" that specify the period of time that must expire from the date that a drug or vaccine was administered to when the animal can safely be consumed by humans. The SRB51 use label prescribes a 21-day withdrawal time for the vaccine to clear an animal. Thus, the NPS will recommend that hunters do not consume harvested meat if a bison was killed within 21 days of being vaccinated. The NPS will continue to notify state wildlife agencies and tribes of forthcoming vaccination efforts through established working groups and communications networks. If hunters consume meat exposed to SRB51 within this window, these indirect impacts would be adverse, short-term, localized and minor given the positive response to antibiotic treatment.

Vaccination of bison is conducted to reduce the rate of abortion and reduce the number of bison infected with brucellosis. By reducing the number of bison infected with brucellosis, this would indirectly reduce the exposure risk to those humans most likely to encounter the bacteria (i.e., wildlife workers conducting necropsies or collecting tissues for research and monitoring; hunters; and slaughterhouse workers). Thus, vaccination would result in an indirect, short and long term beneficial impact to some humans through reduced risk of disease transmission.

Cumulative Impacts

No past, present, and reasonably foreseeable actions listed earlier as occurring within the park and the surrounding area are expected to contribute to cumulative impacts in regards to accidental brucellosis infection or injuries from handling animals during capture facility vaccination, except where brucellosis vaccination with live vaccines occurs in other locations near Yellowstone National Park. The State of Montana could implement a similar brucellosis vaccination program for bison along the west boundary of Yellowstone National Park, though they have only vaccinated nine yearling bison at the Duck Creek capture facility since the implementation of the IBMP began in 2000. Many cattle ranchers in the GYE vaccinate their cattle against brucellosis, some at regular intervals while others vaccinate less frequently (Hendry 2002, Clarke et al. 2005).

In addition, Yellowstone National Park is a wilderness park with a portion of the mission dedicated to providing enjoyment value to visitors. There are many inherent health and safety challenges for humans that pursue their recreational interests, especially in backcountry locations. Every year geothermal features scald a few people that get too close and contact the extremely hot water. The weather can turn cold, creating conditions for hypothermia and frostbite, and the high elevation can cause dehydration for those who fail to consume enough fluids. Some wildlife species can bite, gore, and trample people that approach too closely within the comfort zone of individual animals. While these same risks are present for employees, orientation to and familiarity with safety risks generally make employees more aware and cautious about health and safety needs.

The cumulative impacts to human health and safety would be adverse, localized, and seasonal within the park because the operation period is short and the area used to capture and process the bison is closed to public entry. Safety briefings are a part of each day's operations and all individuals on the field operation team continuously evaluate the safety risks for themselves and their colleagues. Consequently, health and safety risks would be negligible to minor over both the short and long term.

Conclusions

Implementation of Alternative A may result in direct, minor to moderate, short-term, adverse impacts on human health and safety concerns for park employees working with non-sedated, live bison in the capture pen and from handling live bacteria vaccine. No impacts to visitors are expected. If notifications on meat consumption are ignored, impacts to hunters would be adverse, short-term, localized and minor. Cumulative impacts would be negligible to minor over both the short and long term.

4.6.4.2 Impacts from Alternative B (Remote-Delivery Vaccination—Young Bison Only)

The impacts to human health and safety from implementation of Alternative B would include those described for Alternative A, except that remote delivery procedures would constitute a slightly higher degree of human health and safety concern. The remote delivery aspect of Alternative B adds a storage and handling component for field staff implementing delivery and laboratory staff encapsulating the vaccine in the remote delivery projectiles. The remote delivery aspect of Alternative B also adds an encounter probability when working in close proximity to bison throughout their range of distribution. However, the impacts to human health and safety from remote delivery operations are reduced over those impacts from capture pen delivery because the vaccine is encapsulated in a bio-absorbable casing and packaged in a plastic magazine that is specially designed for a tight fit in the compressed air-powered rifle delivery system and, therefore, bison will not be physically handled. Impacts would be direct and indirect, short-term, localized, minor and adverse. If notifications on meat consumption are ignored, given the possibility that more vaccinated bison would be available to hunters, impacts would be adverse, short-term, localized and moderate.

Cumulative Impacts

No past, present, and reasonably foreseeable actions listed earlier as occurring within the park and the surrounding area are expected to contribute to cumulative impacts in regards to accidental brucellosis infection during remote delivery procedures. While bison are generally not threatened by humans when in close proximity, bison behavior can be difficult to predict; especially for inexperienced field technicians.

The Wyoming Game and Fish Department implements a remote vaccination program for elk on 21 feed grounds in northwestern Wyoming. From 1985 to 2002, over 53,000 doses of *B. abortus* vaccine were delivered to elk by humans using a compressed air-powered rifle remote delivery system (Clause et al. 2002). No human exposures resulted from implementing this program for over 20 years. While the potential for significant risks to humans is present, appropriate precautions

The Wyoming Game and Fish Department implements a remote vaccination program on 21 feed grounds in northwestern Wyoming. From 1985 to 2002, over 53,000 doses of *B. abortus* vaccine were delivered to elk by humans using a compressed air-powered rifle remote delivery system. No human exposures resulted from implementing this program for over 20 years.

have mitigated the human health and safety risks for the State of Wyoming personnel. There are no other brucellosis vaccination programs in the GYE using remote delivery methods.

Adverse, localized (though on a larger scale within the park), and seasonal impacts are expected. However, short- and long-term impacts would be minor to moderate when combined with state of Wyoming programs, because the increase in the number of vaccines handled by staff and contractors results in a higher risk of injury than would be expected under Alternative A.

Conclusions
Implementation of Alternative B may result in direct, minor to moderate, and short-term adverse impacts to human health and safety of park personnel from human/wildlife encounters. No impacts to visitor safety are expected.

4.6.4.3 Impacts from Alternative C (Remote-Delivery Vaccination—Young Bison and Adult Females)

The type and magnitude of impacts to human health and safety associated with implementation of Alternative C would be primarily the same as those described for Alternative B. While there would most likely be a greater number of remote vaccine doses delivered during field operations, the impacts would remain localized within the park and generally away from visitor activities. If notifications on meat consumption are ignored, given the possibility that more vaccinated bison would be available to hunters, impacts would be adverse, short-term, localized and moderate.

Cumulative Impacts
While the number of bison vaccinated by remote delivery methods may be greater for Alternative C than for Alternative B, the cumulative impacts to human health and safety risks are similar to those described above under Alternative B.

Conclusions
Implementation of Alternative C may result in direct, minor to moderate, and short-term adverse impacts to human health and safety of park personnel from the increased time personnel spend in close proximity to wild bison while implementing the remote delivery program. No impacts to visitor safety are expected.

4.6.5 Visitor Use and Experience

Impacts to visitor use and experience were assessed by determining the current condition of visitor use and experience likely to be affected by the alternatives, and by identifying the impacts on these from a vaccination program implemented under each alternative. The geographic area of analysis for visitor use and experience was limited to inside the park boundary.

Wildlife viewing is a popular activity that has been increasing since the 1980s (Manfredo and Larsen 1993). Visitors to Yellowstone National Park rate observation of wildlife as an important feature of their visitor experience (Manni et al. 2007). However,

> Some constituencies hold deeply rooted values that management actions to manipulate wildlife in national parks should not be undertaken. Therefore, the experience of these constituencies is negatively affected at parks conducting more intensive wildlife management programs. The divergent nature of public opinion about bison management issues provides little room for general consensus.

stakeholders interested in bison management issues have diverse values, perspectives, and beliefs that may conflict with management options preferred by decision makers (Duffield et al. 2000a,b; Gates et al. 2005). Some constituencies hold deeply rooted values that management actions to manipulate wildlife in national parks should not be undertaken. Therefore, the experience of these constituencies is negatively affected at parks conducting more intensive wildlife management programs (Fulton et al. 2004). The divergent nature of public opinion about bison management issues provides little room for general consensus.

The thresholds of intensity used to describe the impacts of the proposed actions on visitor use and experience are as follows:

- *Negligible*—the impacts would be barely detectable and/or would affect few visitors because they would not likely be aware of the effects associated with proposed changes to management actions.
- *Minor*—the impacts would be detectable and only affect some visitors. Visitors would be aware of the effects associated with management actions. The detectable changes in visitor use and experience would be slight, but visitor satisfaction would not be measurably affected.
- *Moderate*—the impacts would be readily apparent and affect many visitors. Visitors would be aware of the effects associated with management actions. Visitor satisfaction might be measurably affected, with visitors either being satisfied or dissatisfied. Some visitors would choose to pursue activities in other available local or regional areas.
- *Major*—the impacts would affect the majority of visitors. Visitors would be highly aware of the effects associated with management actions. Changes in visitor use and experience would be readily apparent. Some visitors would choose to pursue activities in other available local or regional areas.

The method used to identify impacts to visitor use and experience includes assessing how the proposed alternatives affect a visitor's ability to experience the natural and cultural resources and the ability for visitors to access a diverse spectrum of recreational opportunities. Impacts to visitors from park operations vary based on individual expectations. These expectations are often a result of the level of experience a visitor may have at Yellowstone National Park or other similar national park units. Visitors have noted that scenic views and the preservation of native plants and animals are important features drawing them to visit the park (Duffield et al. 2000a, b; Manni et al. 2007).

4.6.5.1 Impacts from Alternative A (No Action—Boundary Capture Pen Vaccination of Calves and Yearlings)

> Under Alternative A the direct impacts to park visitors are that they do not have access to about 2,000 acres of the Gardiner basin during bison management operations.

Under the No Action Alternative, no changes would occur regarding the types of recreational opportunities and experiences that are available to park visitors. The direct impacts to park visitors are that they do not have access to about 2,000 acres of the Gardiner basin during bison management operations. While the area surrounding the capture facility is closed to visitor access, that area is open, highly observable habitat and visitors may still view wildlife in the area from a distance. Vaccination operations are short in duration and localized at the Stephens Creek administrative facility. During public scoping some individuals noted that they would be annoyed by knowing Yellowstone bison are vaccinated with brucellosis vaccines regardless of whether they actually observed any of the field operations occurring. Given the limited area for vaccination under Alternative A, impacts to visitor experience and safety would be indirect, localized, short-term, adverse, and negligible.

Cumulative Impacts

Past, present, and reasonably foreseeable actions occurring within the park and the surrounding area that would be expected to contribute to cumulative impacts include other capture/vaccination facilities as well as hunting.

The geographic area for cumulative impacts includes the area of tourism industry in the GYE which is much larger than Yellowstone National Park and includes Grand Teton National Park, two wildlife refuges, and seven national forests. Recreational opportunities for visitors in the GYE are abundant for those who want to experience the natural and cultural resources protected on public and private lands. Visits to Yellowstone National Park are typically only a portion of a visit to a wide variety of destinations elsewhere in the GYE or the greater three-state area.

The State of Montana implements a similar capture and vaccination program outside the west boundary of the park. In addition, the state manages a bison hunting program that occurs in two areas on public and private lands adjacent to Yellowstone National Park. Both of these programs result in direct, short-term, localized, minor impacts to visitors when they encounter those activities. Inputs could be both adverse and beneficial depending on personal perspectives. The impacts of these related actions, in conjunction with the impacts of Alternative A would result in short and long term, negligible to minor, adverse and beneficial cumulative impacts to visitor experiences in Yellowstone National Park depending on their feelings about bison conservation or reducing brucellosis infection in bison through vaccination.

Conclusions

Implementation of Alternative A would result in negligible, short-term, localized, indirect, adverse impacts on visitor use opportunities and associated experiences visitors seek in Yellowstone National Park. Cumulative impacts would be long term, negligible to minor, adverse and beneficial cumulative impacts to visitor experiences in Yellowstone National Park depending on their feelings about bison conservation or reducing brucellosis infection in bison through vaccination.

4.6.5.2 Impacts from Alternative B (Remote-Delivery Vaccination—Young Bison Only)

The impacts to visitor use and experience from implementation of Alternative B would include those described for Alternative A. The opportunity for visitors to encounter park staff while conducting remote vaccination operations would increase under Alternative B, but still be low. For vaccine delivery to be most successful, there needs to be limited activities occurring in the vicinity of individual bison groups being vaccinated. Thus, park staff will selectively choose to work around groups of bison where they are more removed from other human encounters. The implementation time period occurs during non-peak time periods of visitation. However, a portion of visitors may be adversely affected by knowing that vaccination operations are being conducted at Yellowstone National Park and/or seeing bison marked via biobullet or paint-ball gun during remote delivery operations.

The wounding of a bison during vaccine delivery is possible, but the probability is low. Necropsies of animals receiving biobullet implants during a controlled study detected lesions in 80% of animals after 7 days, 20% of animals after 14 days, and zero animals after 21, 28, and 35 days following vaccine delivery (Morgan et al. 2004). Quist and Nettles (2003) noted that the degree of injury to animals from a compressed air-powered rifle projectile is insignificant in most cases. However, visitors are generally sympathetic toward injured animals. Human dimensions studies note that a satisfactory experience depends largely on a person's values toward wildlife and their motivation to understand how wildlife systems function (Manfredo et al. 1995). Given the limited visibility of activities, but increase in opportunity of seeing marked animals, impacts would be short-term, localized, indirect, minor adverse impacts on visitor use opportunities and associated experiences.

Cumulative Impacts

Overall, the cumulative impacts of past, present, and future bison management projects on visitor use and experience would be minor, adverse and beneficial over both the short and long term. The cumulative impacts of vaccination in addition to other bison management actions would depend on who the individual visitor may be. Whether those impacts would be adverse or beneficial would depend on an individual’s attitude toward brucellosis management and how they view the appropriateness of wildlife management actions within and adjacent to a national park.

Conclusions

Implementation of Alternative B would create minor, short-term, indirect impacts on visitor use opportunities and associated experiences visitors seek in Yellowstone National Park. Impacts would be beneficial for those visitors that support the protection of Montana’s cattle industry and maintaining its brucellosis class-free status. However, a portion of visitors may be adversely affected by knowing that vaccination operations are being conducted at Yellowstone National Park, regardless of whether they ever encounter field operations. Cumulative impacts would be minor, adverse and beneficial over both the short and long term.

4.6.5.3 Impacts from Alternative C (Remote-Delivery Vaccination—Young Bison and Adult Females)

The type and magnitude of impacts to visitor use and experience associated with implementation of Alternative C would be generally the same as those described for Alternative B. While there would be a greater time period for field operations to occur, the impacts would remain localized within the park and generally away from visitor activities. These impacts would be minor, short-term, indirect impacts on visitor use opportunities and associated experiences visitors seek in Yellowstone National Park.

Cumulative Impacts

Overall, the cumulative impacts of past, present, and future bison management projects on visitor use and experience would be minor, adverse and beneficial over both the short and long term; similar to those described in Alternative B.

For Alternatives B and C impacts would be beneficial for those visitors that support the protection of Montana’s cattle industry and maintaining its brucellosis class-free status. However, a portion of visitors may be adversely affected by knowing that vaccination operations are being conducted at Yellowstone National Park, regardless of whether they ever encounter field operations.

Conclusions
Implementation of Alternative C may create minor, short-term, indirect impacts on visitor use opportunities and associated experiences visitors seek in Yellowstone National Park. Impacts would be beneficial for those visitors that support the protection of Montana's cattle industry and maintaining its brucellosis class-free status. However, a portion of visitors may be adversely affected by knowing that vaccination operations are being conducted at Yellowstone National Park, regardless of whether they ever encounter field operations.

4.6.6 Park Operations

Impacts expected to occur relative to NPS operations are assessed based on the effects of the vaccination program relative to the workload of park staff and changes in number of staff required to implement each alternative. The information in this section is based on knowledge obtained by members of the Bison Ecology and Management Program at Yellowstone National Park and through conversations with other park employees. The geographic analysis for park operations was limited to inside the park boundary.

The definitions for identifying thresholds of intensity used to describe the impacts of the proposed actions on park operations are summarized below:

- *Negligible*—impacts would be slight to non-detectable; no changes to workload would be detectable or no additional staff would be added.
- *Minor*—impacts would be detectable with slight changes to workload or staff, but only to a small portion of the park operations outside and within the Bison Ecology and Management Program.
- *Moderate*—impacts would be detectable to a modest proportion of park operations with changes to workload and staff required.
- *Major*—impacts would be detectable to a majority of park operations in regards to workload and staffing.

4.6.6.1 Impacts from Alternative A (No Action—Boundary Capture Pen Vaccination of Calves and Yearlings)

The no action alternative includes collaboration with colleagues that conduct hazing and capture operations, and those who operate capture facility trap and squeeze chute gates to sort bison for age-specific bison vaccination. Current operations are localized at the Stephens Creek corral and holding paddocks northwest of Gardiner, Montana. No additional staff would be needed for implementing Alternative A. Current staffing includes wranglers, law enforcement rangers, maintenance personnel, education and public information staff, wildlife biologists and other scientists, park management personnel, and purchasing/procurement staff. Short-term, direct, localized, adverse, negligible impacts to staff and workload come from collaborative efforts to handle groups of bison, care for individuals that are held in the facility, purchasing supplies needed for vaccination, and maintenance of the facility. Long-term, localized, indirect, adverse, negligible impacts to operations

> Vaccination of bison generates wide-spread interest by many constituency groups. Consequently, long term, indirect impacts to park operations include careful compilation of information and sharing through reports and press releases.

would include maintenance, repair, and upgrade of the facility. Regular maintenance of the facility is necessary to keep it safe for humans and the bison.

Vaccination of bison generates wide-spread interest by many constituency groups. Consequently, long term, indirect impacts to park operations include careful compilation of information and sharing through reports and press releases. The public information team manages written and oral contacts with media, partner agencies, and public interest groups and individuals.

Alternative A has a minimal effect on population-level brucellosis prevalence. Thus its implementation will not greatly inform the social debate about managing the risk of brucellosis transmission. The beneficial effects of this alternative are that new information can be attained through the adaptive management process to gain a greater understanding of the implications and effects of vaccinating bison in the northern GYE. This understanding can be used to resolve regional and social conflicts in regards to bison management.

Cumulative Impacts

Past, present, and reasonably foreseeable actions occurring within the park and the surrounding area that would be expected to contribute to cumulative impacts to park operations include a wide variety of tasks such as maintenance of facilities, education of visitors, law enforcement, maintaining working relationships with colleagues in other agencies adjoining Yellowstone National Park, and monitoring of natural and cultural resources to ensure they are protected for future generations. Vaccination actions would be conducted only when hazing of bison becomes ineffective at maintaining spatial separation from private properties north of the park boundary. Budget and staffing would remain at current levels. However, staff time spent studying the feasibility of expanding vaccination program would be additive to the current vaccination program.

The cumulative impacts of these related actions to park operations would result in short-term, adverse, localized, and minor to moderate impacts to the programs that implement capture, test, and vaccination procedures. However, the long-term impacts of vaccinating bison are expected to produce beneficial, moderate impacts for park staff that work with other agencies to resolve regionalized political and social conflicts.

Conclusions

Implementation of Alternative A would create negligible to minor, short term, localized, direct, adverse impacts on park operations. The cumulative impacts of these related actions to park operations would result in short-term, adverse, localized, and minor to moderate impacts to the programs that implement capture, test, and vaccination procedures. However, the long-term impacts of vaccinating bison are expected to produce beneficial, moderate impacts for park staff that work with other agencies to resolve regionalized political and social conflicts.

4.6.6.2 Impacts from Alternative B (Remote-Delivery Vaccination—Young Bison Only)

Impacts associated with Alternative A would also pertain to Alternative B. Additional direct impacts resulting from Alternative B would be associated with administering the remote vaccination program and affect the Bison Ecology and Management Program more than any other work group in the park. These impacts are discussed below but, in summary, impacts would be direct or indirect, localized, short- and long-term, adverse and minor to moderate.

Staff would be required to maintain high skill levels in operating specialized equipment, handling and documenting use of vaccine, and conducting monitoring efforts needed to evaluate the effects and effectiveness of the program. Safety and skill training would be persistent and long-term. Impacts to workload from training would be short-term, localized, adverse and minor.

Remote delivery will be conducted by relatively few staff on only one or two groups of bison at a time. Consequently, direct, adverse impacts to park operations (other than bison management personnel) would be localized, minor, and short-term during the implementation of field delivery activities and remote monitoring of bison. Most of the vaccination activities would be carried out in the backcountry. However, there could be occasional traffic delays for park staff along roadways during periods when park roads are closed to motor vehicles operated by visitors. These delays would be short-term, localized, adverse, and minor if park employees encounter vaccination operations along roads and trails while bison are moving along those maintained corridors. There may be increased short-term communication needs with park dispatch and staff encountering field operations to provide safe transport near road corridors when remote vaccination operations are conducted nearby. Roadway delays and dispatch time would be adverse, negligible to minor, and short-term.

Monitoring of population ecology and disease responses to a remote vaccination program would require increased funding or the cessation of other ecological monitoring currently conducted by existing staff. These impacts would be long-term, adverse, and minor to moderate.

There would be an increased level of inquiry by public parties contacting the education and public affairs work groups wanting to follow the status of the program and learn about the results of the implementation and monitoring activities. There would also be increased reporting needs for the Superintendent and natural resource managers in sharing information with partners, politicians, and NPS leadership regarding monitoring and implementation activities. These types of impacts would be localized, adverse, minor to moderate, and long-term.

Another long-term, adverse, moderate impact of this alternative is that the implementation of a remote vaccination program would require additional duties by staff in the Bison Ecology and Management Program to contract the manufacturing of vaccine encapsulated into the appropriate quantity of delivery vessels and to physically travel the landscape to distribute the vaccine to bison throughout their range. These duties would entail a moderate increase in work activities or a moderate replacement of other activities currently being conducted.

There would be additional contracting needs with companies that manufacture remote delivery projectiles encapsulated with vaccine. Impacts to park contracting personnel would be short in duration and additional staffing would not be necessary. A long-term, moderate, beneficial impact would be that management discussions with partner agencies would systematically take a new perspective, providing the potential for new management opportunities, as seroprevalence in the population decreased.

Bison travel corridors exist in many locations where landscape features like streams and canyon areas constrict efficient travel about the park (Bruggeman et al. 2006, 2007). The NPS maintains roads and trails in many locations where these landscape features connect seasonal bison ranges. The constricted nature of the landscape in some areas (e.g., canyons) limits efficient travel routes. Consequently, bison tend to move along road and trail corridors during all times of the year through these types of landscape features. The trail system over the central plateau from the upper Nez Perce Creek past Mary Lake and into Hayden Valley through the Highland Hot Springs is a good example of trail networks that the central bison population use extensively (Bjornlie and Garrott 2001, Clarke et al. 2005, Gates et al. 2005). Similarly, Gneiss Creek and Howard Eaton trail north of Fishing Bridge are used by bison; these may be areas where park maintenance crews intermittently work during the time period of remote vaccination operations. Work delays due to the operations would be short-term, adverse and minor.

Remote delivery vaccination of calves and yearling female bison may occur during March through May. During this time period, certain portions of Yellowstone National Park known as bear management areas are generally closed to human access to minimize disturbance to grizzly bears. However, some park management activities are allowed in these areas if a review process by the park's Bear Management Office determines that the proposed activities are compatible with bear management objectives. NPS staff conducting remote delivery vaccination may request access to bear management areas near Gneiss Creek, Richards Pond, Blacktail Deer Plateau, and the Firehole Canyon to Old Faithful. If access is granted, staff will avoid working near locations where grizzly bears are observed, encountered, or known to be active. NPS staff will also avoid locations with ungulate carcasses that may be used by grizzly bears. Impacts to workload as schedules are adjusted would be short-term, localized, adverse and minor.

Cumulative Impacts

Past, present, and reasonably foreseeable actions occurring within the park and the surrounding area that would be expected to contribute to cumulative impacts include all those described in Alternative A. Cumulative impacts to park operations resulting from Alternative B would be more likely to affect the administrative and educational duties of park employees outside the Bison Ecology and Management Program. Under Alternative B, staffing and budgetary needs for Bison Ecology and Management Program would increase throughout the year. Other work groups may not receive staffing increases, but would be required to interact with bison management personnel more often. Implementation of remote vaccination is expected to increase staff duties in providing field logistics, coordination with contractors for supplies and materials, and filling information requests by interested parties.

The increase in number of vaccines delivered remotely by staff is expected to become more efficient as the park gains more experience in conducting this program.

Adverse, localized and seasonal impacts to other programs are expected from the increased work load of implementing a remote vaccination program. Short- and long-term impacts would be minor to moderate because of the increased complexity of the program. The increase in number of vaccines delivered remotely by staff is expected to become more efficient as the park gains more experience in conducting this program.

Conclusions

In summary, impacts would be direct or indirect, localized, short- and long-term, adverse, and minor to moderate for bison management staff and other staff. Impacts to the bison management staff would be moderate and regional in scope to communicate with area management partners, the GYE Brucellosis Committee, and the National Brucellosis program administered by the Washington Office of USDA.

4.6.6.3 Impacts from Alternative C (Remote-Delivery Vaccination—Young Bison and Adult Females)

In general, direct impacts under Alternative C would be similar to those described under Alternative B. For the remote vaccination program, staff would require more time to maintain high skill levels in operating specialized equipment, handling and documenting use of the vaccine, and conducting monitoring efforts to evaluate the effects and effectiveness of the program. Safety and skill training would be persistent and long-term. Impacts to park staff traveling to work sites may be more numerous since remote delivery operations would be attempting to vaccinate a higher proportion of the bison population. Impacts would be short- and long-term, adverse, and minor to moderate.

Similar to Alternative B, there would be additional contracting needs with companies that manufacture remote projectiles encapsulated with vaccine, and the contract funding amounts would be higher because more vaccine would be needed to vaccinate a larger proportion of the bison population. Monitoring of population ecology and disease responses to the remote vaccination program would require increased funding or cessation of other monitoring currently being conducted. These indirect impacts would be short- and long-term, adverse, and minor to moderate in scope.

Alternative C would have the same general impacts as Alternative B. One difference would be that the labor needed for staff to deliver more vaccine to a larger proportion of the bison population would have a long-term, moderate impact on work load for the Bison Ecology and Management Program. Remote delivery will be conducted by few staff on one or two groups of bison at a time. Consequently, adverse impacts to park operations (other than bison management personnel) would be very localized, minor, and short-term during the implementation of field delivery activities and remote monitoring of bison.

Also, the contracting office, dispatch office, and the public information staff may experience minor increased workloads. One long-term, moderate, beneficial impact of Alternative C compared to Alternative B is that seroprevalence in the bison population should decrease faster. Thus, management discussions with partner agencies should systematically advance due to new management opportunities resulting from decreases in population seroprevalence.

Cumulative Impacts

While the number of bison vaccinated by remote delivery methods may be greater for Alternative C than for Alternative B, the cumulative impacts to park operations would be similar.

Conclusions

The increased number of bison to be vaccinated would result in a minor to moderate adverse impact to park operations. The impacts would mostly affect the Bison Ecology and Management Program. Another impact to the bison management staff that would be moderate and regional in scope requires communicating with area management partners, the GYE Brucellosis Committee, and the National Brucellosis program administered by the Washington Office of USDA. One moderate to major, long-term, regional, indirect, beneficial impact would be that management discussions with partner agencies would systematically advance due to new management opportunities resulting from decreases in population seroprevalence. Cumulative impacts to park operations would be similar to Alternative B.

4.7 Irreversible or Irretrievable Commitments of Resources

An irreversible commitment of resources is defined as the loss of future options. The term applies to the effects of using nonrenewable resources such as minerals or cultural resources, or to the loss of an experience as an indirect effect of a permanent change in the nature or character of the land. An irretrievable commitment of resources is also defined as the loss of production, harvest, or use of natural resources. The amount of production forgone is irretrievable, but the action is not irreversible. If the use changes, it is possible to resume production. Irreversible commitments are those that cannot be overturned, except perhaps in the extreme long term. Irretrievable commitments are those that are lost for a period of time. The irretrievable and irreversible commitments of resources that are associated with each alternative are summarized below.

Under Alternative A, no specific actions would be taken to change any of the natural or cultural resources, visitor experience, or park operations relative to how bison vaccination procedures are described in the IBMP and implemented under the Interagency Field Operating Procedures. Under Alternatives B and C, no appreciable irretrievable or irreversible commitments of resources would be associated with bison, other wildlife, ethnographic resources, human health and safety, visitor use and experience, or park operations. The irretrievable and irreversible commitments of resources associated with Alternatives B and C would be limited to the human resources involved with evaluating and planning remote delivery vaccination, requesting a permit to implement remote vaccination from USDA, developing agreements for supplies and materials used in remote vaccination, and purchasing equipment necessary to implement the selected alternative.

4.8 Relationship between Local Short-term Uses and Maintenance and Enhancement of Long-term Productivity

While the local short-term use of remote vaccination of calves and yearlings in Alternative B will lead to some negligible to minor adverse impacts, the long term reduction in the risk of brucellosis transmission will enhance the long term sustainability and management options for bison. Long term enhancement will be increased under Alternative C, because remote vaccination would includes adult females. This additional effort would lead to a major, direct, long-term, benefit toward bison conservation. Repeated vaccination of individual bison will result in long-term vaccination protection for the population and help to sustain a higher level of herd immunity, in turn leading to higher levels of calf production and increased tolerance for bison on ranges outside Yellowstone National Park. Thus, long term conservation of the population may improve.

4.9 Adverse Impacts That Could Not Be Avoided

Impacts to individual bison and other wildlife that directly contact vaccine strain *Brucella abortus* are unavoidable. *Likewise,* impacts to individual humans that share the opinion regarding disapproval of wildlife vaccination are unavoidable. Unavoidable adverse impacts are disclosed throughout the impact topics of the environmental consequences. Mitigation measures common to action alternatives ensure that adverse impacts remain at the negligible to minor level especially at the animal and human population perspective.

5. Chapter 5: Consultation and Coordination

5.1 History of Public Involvement

The public has a right to know about the challenges confronting the NPS and to participate in the process of developing solutions for those challenges (NPS Directors Order 75). The NPS role during public involvement is to provide opportunities for the interested and affected public to be involved in meaningful ways, listen to their concerns and values, and consider this input when shaping decisions and policies. Public participation in the planning process ensures that the NPS fully understands and considers the public's interest.

> The public has a right to know about the challenges confronting the NPS and to participate in the process of developing solutions for those challenges.

Through public involvement, the NPS shared information about the planning process, issues, and proposed actions. In turn, the planning teams were informed of the concerns and values of those groups and individuals that participated in the process. Government agencies and other public constituencies were consulted as part of public involvement process. Public and agency participation during the planning process allowed the planning team to (1) analyze and incorporate comments from previous planning efforts, (2) collect scoping comments to help define the range of issues to be addressed, (3) provide opportunities for the public to obtain the knowledge necessary to make informed comments, and (4) consult with other management agencies.

In response to public discussion about whether brucellosis transmission by elk or bison is a threat to domestic livestock and whether vaccination along with other management strategies might be useful in controlling potential transmission, the Secretary of the Interior requested a six-month study of brucellosis in the GYE by the National Academy of Sciences. This study was completed in 1998 by the National Research Council (Cheville et al. 1998). Findings of this study included:

- A brucellosis program for wildlife in the GYE should be approached in an adaptive management framework.
- Vaccination is an essential component of any program to control brucellosis.
- Any vaccination program for bison must be accompanied by a concomitant program for elk (Note: no vaccination program for elk has been initiated in the northern portion of the GYE where Yellowstone bison reside).
- If the current vaccination program on elk feeding grounds in Wyoming (outside Yellowstone National Park) is continued, then it should include collection of serologic and culture data and appropriate epidemiologic analysis.
- An effective vaccination program would aid in reaching short-term disease control measures. Consequently, a long-term, controlled vaccination study must be conducted to assess the complete role of vaccination in brucellosis control for bison and elk.

A brucellosis vaccine and diagnostics workshop was held by the U.S. Animal Health Association August 16-18, 2005. The NPS is a board member of this organization and was an active participant in the planning and implementation of the workshop. Forty-three participants from the United States, Canada, Russia, and New Zealand were invited based upon their scientific expertise in vaccine development, disease diagnostics, and vaccine delivery systems. These experts willingly shared their thoughts and expertise to establish a future course of action, including that:

Experts willingly shared their thoughts and expertise to establish a future course of action, including that managers should dramatically increase the use of established brucellosis vaccines in elk, bison, and cattle in the GYE.

1. managers should dramatically increase the use of established brucellosis vaccines in elk, bison, and cattle in the GYE;
2. research scientists should move forward with experiments to evaluate the effectiveness of novel existing vaccines in cattle, bison and elk; and
3. an investment in better tools is needed for short-term control of brucellosis in wildlife, which should set the stage for eventually eliminating this disease in the long-term (U.S. Animal Health Association 2006).

Two presentations were given to the Brucellosis Committee of U.S. Animal Health Association during October 2005 and October 2006. These presentations summarized the feasibility of implementing a remote vaccination program for delivering vaccine to free-ranging Yellowstone bison and described the quantitative model for estimating the impacts each vaccination alternative would have on population seroprevalence (Wallen et al. 2005).

5.1.1 Internal Scoping

The IBMP directed the expansion of an in-park remote vaccination program when the technology became feasible. The feasibility of moving forward with vaccination of bison has been discussed by park staff at many meetings and a preliminary assessment was summarized during a status review of the IBMP (Clarke et al. 2005). Yellowstone National Park engaged the services of Greystone Environmental Consulting during October 2002 to assist in the planning process. Initial scoping meetings began at that time to discuss the issues, purpose and need for the action, as well as how the park would engage public constituencies. During 2003 and 2004, NPS staff summarized the park’s enabling legislation, purpose and significance, and historic and current issues and strategies for bison management. An interdisciplinary planning team developed the purpose and need for action, project objectives, issues and impact topics, stakeholders and other parties potentially interested in this project, a framework for the public participation strategy, protocols and points of contact for project coordination and communication, and project schedule. Preliminary issues that were identified during the internal scoping process included:

1. What decision did Yellowstone National Park need to make?
2. Was there adequate information to determine whether SRB51 is low risk for use in bison?
3. Was there sufficient understanding of Yellowstone bison ecology to develop a feasible remote delivery program?

> Yellowstone National Park has hosted consultation meetings with tribal representatives to discuss National Park Service management of the park and share information about issues important to associated tribes.

Yellowstone National Park has hosted consultation meetings with tribal representatives to discuss NPS management of the park and share information about issues important to associated tribes. Discussion of the remote vaccination program planning process began in May 2003 and continued in following years. Transcripts and attendance records are available for reference to topics discussed and identification of those in attendance at these meetings. Also, NPS employees from Yellowstone National Park periodically travel to meet with tribal representatives at their respective locations. NPS representatives made trips to Pierre, South Dakota in October 2003 to meet with many tribes from this region and shared information about the potential remote vaccination of Yellowstone bison. In addition, park staff went to Blackfoot, Idaho in November 2004 and October 2005 to meet with representatives from Fort Hall, where bison management and vaccination issues were part of the broader conversation. In December 2004, the Superintendent sent letters to 198 tribal representatives from 25 tribes informing them of this environmental study and requesting input regarding the effects of remote vaccination on Yellowstone bison.

5.1.2 Public Scoping

Public scoping for the bison vaccination program was initiated on August 3, 2004, when the Notice of Intent to Prepare an EIS was published (69 FR 46564). Public scoping newsletters were mailed to 155 individuals and organizations during August 2004 to provide (1) information on the scope of the proposed action, (2) the purpose of, need for, and description of the proposed action, and (3) opportunities to provide comments, including dates and times for planned open house meetings. The letter also included instructions on how to submit comments by mail, facsimile, e-mail, and by using an automated comment form available on the project website at <http://www.nps.gov/yell/remote-vaccination> (page no longer active). The public was encouraged to provide their comments by October 2, 2004. Comments received within five days following the deadline for submission were accepted. In addition, announcements for the open house meetings were published in six local newspapers, including the Bozeman Daily Chronicle, Billings Gazette, Cody Enterprise, West Yellowstone News, Jackson Hole Guide, and Associated Press Livingston Enterprise. The scoping schedule was posted on the project webpage on the park website.

Open house meetings were held during the week of September 12, 2004. Four regional locations were selected for these meetings so that interested parties could participate. The schedule for the public scoping open house meetings was (1) Gardiner, Montana on September 13, (2) Bozeman, Montana on September 14, (3) Idaho Falls, Idaho on September 15, and (4) Cody, Wyoming on September 16. Meetings were organized in an open-house format, allowing the public to browse informational posters, interact with park staff, and listen to a brief presentation at their own pace. Meetings were available to the public between 1800 and 2100 hours. A series of full-color display boards was presented to illustrate the project background and potential environmental impacts, issues, concerns, and alternatives used at other parks facing similar management issues. These display boards provided an overview of the NEPA process, general project issues, and current management practices at the park. Park and contracting staff were located at the display boards to answer questions, facilitate discussions, and record thoughts, ideas, and concerns raised by the public.

A total of 37 people attended public meetings. Representatives from the park's Bison Ecology and Management Program and Greystone Environmental Consulting attended and facilitated all four public scoping meetings. A total of 126 comment documents were received during the public scoping period. Most of these letters were received via e-mail, U.S. mail, and comment forms collected at the open houses. In addition, 11 individuals provided comments using the project website. More than 800 specific comments within the 126 documents were tallied. The NPS also considered 90 comments regarding vaccination of bison that were recorded during the planning process for the IBMP. These comments were organized into 13 issues that either supported implementing a vaccination program or indicated the vaccination of bison was unnecessary or would not accomplish the goals of the program. The conclusion of the FEIS for the IBMP was that vaccination provides the most effective non-lethal means of decreasing disease prevalence in bison.

A total of 126 comment documents were received during the public scoping period. Most of these letters were received via e-mail, U.S. mail, and comment forms collected at the open houses. In addition, 11 individuals provided comments using the project website. More than 800 specific comments within the 126 documents were tallied. NPS staff also considered 90 comments regarding vaccination of bison that were recorded during the planning process for the Interagency Bison Management Plan.

The conclusion of the Final Environmental Impact Statement for the Interagency Bison Management Plan was that vaccination provides the most effective non-lethal means of decreasing disease prevalence in bison.

5.1.3 Alternative Development Meeting

Staff from Greystone Environmental Consulting and Yellowstone National Park met in March and May of 2005 to identify preliminary alternatives for inclusion in the EIS. These ideas were summarized and presented to park managers at the Yellowstone Center for Resources in August 2005, and reviewed with park leadership in October 2005.

5.1.4 Agency Consultation

Pursuant to Section 7 of the Endangered Species Act of 1973, as amended, the NPS initiated consultation with the USFWS during the public scoping period. Consultation with staff in the Cody, Wyoming office led to a draft biological assessment that was presented to the level one consultation team at a meeting in Moose, Wyoming during October 2006. The biological assessment was subsequently submitted to the Cheyenne office of USFWS through letter of transmittal from the park superintendent in November 2006. The biological assessment determined that the proposed actions may affect, but are not likely to adversely affect the bald eagle, Canada lynx, grizzly bear, and gray wolf. The USFWS concurred with this assessment (Appendix K). The bald eagle has since been removed from the federal List of Endangered and Threatened Wildlife and Plants.

The biological assessment determined that the proposed actions may affect, but are not likely to adversely affect the bald eagle, Canada lynx, grizzly bear, and gray wolf. The U.S. Fish and Wildlife Service concurred with this assessment.

Initial consultation with the Montana and Wyoming offices of the State Historic Preservation Officers was conducted during June 2005. The NPS initially informed these offices of its intent to include an assessment of effects on cultural resources as part of the draft EIS. Subsequent analyses led the NPS to initiate a separate consultation that determined alternatives B and C for vaccination of free-ranging bison may have an impact on historic properties, but no historic properties would be adversely affected by the undertaking. The State Historic Preservation Officers concurred with this assessment (Appendix G).

On September 18, 2007, NPS staff briefed the Animal and Plant Health Inspection Service in Fort Collins, Colorado on the status of planning for bison remote delivery vaccination, including a review of the bison brucellosis model forecasting the effects of vaccination, surveillance plans, and the proposed environmental compliance schedule (Treanor et al. 2007a, b).

On August 28-29, 2008, NPS staff briefed the IBMP partners and attending public in Mammoth, Wyoming on the surveillance plan for Yellowstone bison. On October 15-16, 2008, NPS staff briefed the IBMP partners and attending public in Helena, Montana on the status of this EIS for remote delivery vaccination of Yellowstone bison. Copies of briefing statements, presentations, and meeting summaries that include comments from the public at the end of each meeting are posted on the world-wide web at <www.ibmp.info>.

5.2 Preparers and Consultants

5.2.1 Interdisciplinary Planning Team—NPS, Yellowstone National Park

Rick Wallen	Wildlife Biologist (Project Manager)
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John Treanor	Wildlife Biologist
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Linda Mazzu	Compliance Specialist
Julie York	Park Planner
Chris Geremia	Biological Technician
Janice Stroud	Biological Technician
Dr. Ann Johnson	Archeologist
Elaine Hale	Archeologist
Tim Reid	Assistant Chief Ranger
Dan Reinhart	Resource Management Coordinator

5.2.2 Significant Contributors—NPS, Yellowstone National Park and other collaborators

Dr. Kerry Murphy	Wildlife Biologist—assistance with biological assessment and consultation with USFWS
Doug Blanton	Biological Technician—assistance with biological assessment
Tildon Jones	Biological Technician—assistance with biological assessment
Rosemary Sucec	Cultural Anthropologist—assistance with consultation with American Indian tribes and assessment of impacts to ethnographic resources
Roger Anderson	Branch Chief of Cultural Resources—assistance with State Historic Preservation Office consultation
Stephanie Cole	Clerical Assistant—assistance in compiling EIS
Wayne Brewster	Deputy Director—assistance with internal scoping
Chris Lehnertz	Deputy Superintendent—review and comment
Colin Campbell	Deputy Superintendent—review and comment

A cooperative agreement was established with the University of Kentucky to collaborate on development of an analysis model for assessing the environmental consequences of implementing the three alternatives. The modeling process took approximately two years and was mentored by Drs. Phil Crowley and Dave Maehr. During this modeling effort, many colleagues were contacted for opinions about brucellosis epidemiology and pathogenesis. The model results were peer reviewed by individuals familiar with brucellosis dynamics. Subsequently, an invited group of specialists gathered to review and comment on outputs at the NPS offices in Fort Collins, Colorado during September 2006. Model results were also presented to the Brucellosis Committee of the U. S. Animal Health Association during October 2006 (Treanor et al. 2007a). Significant contributors during this process were:

Dr. Steven Olsen	USDA, Animal Research Service, National Veterinary Science Ames, Iowa
Dr. Margaret Wild	Biological Resources Management Division, NPS, Fort Collins, Colorado
Dr. Steven Sweeney	Wildlife Veterinarian, Bozeman, Montana
Dr. Phillip Elzer	Professor, Louisiana State University
Dr. John Gross	Wildlife Biologist, NPS, Fort Collins, Colorado
Dr. Terry Kreeger	Wildlife Veterinarian, Wyoming Game and Fish, Sybille Wildlife Research Unit, Wheatland, Wyoming
Keith Aune	Director of Wildlife Research, Montana Fish, Wildlife, and Parks, Helena, Montana
Dr. Jack Rhyan	Wildlife Research Scientist, USDA, Animal and Plant Health Inspection Service, Veterinary Services, Fort Collins, Colorado
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5.2.3 Third-party Contractors—Greystone Environmental Consulting and ARCADIS-Greystone

Deb Balheim	Editor	Editorial Review
Lucy Bambrey	Project Manager/Senior Cultural Resources Specialist	Project management; document review; quality control; technical review and oversight; cultural resources, public involvement
Eric Cowan	CAD Specialist	Drawings and figures
Jason Gregory	GIS Specialist	GIS analysis; mapping
Audrey Hanbury	Word Processor	Word processing
John McDonald	Assistant Project Manager/ Wildlife Specialist	Project management; wildlife and wildlife habitat, threatened and endangered species; human health and safety
Melissa Sartorius	GIS Specialist	GIS analysis; mapping
Dr. Carl Spath,	Senior Cultural Resources Specialist	Cultural resources, ethnographic resources
Susan Riggs	Project Manager	Project management; document review; quality control; human health and safety; socioeconomics and visitor experience resources
Chris Rutledge	Senior Biologist / NEPA Technical Reviewer	NEPA technical review
Randy Schroeder	Principal-in-Charge	Document review; quality control, public involvement
Lisa Welch	Senior Resource Specialist	Visitor use, including visual and aesthetic resources, socioeconomics
Carrie Womack	Project Assistant	Administrative record, Public involvement, word processing

5.2.4 Third-party Contractors—Big Sky Institute

Scott Bischke	Technical Editor	Editorial review of EIS

5.2.5 NPS Reviewers of Previous Draft of the EIS

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6. Glossary of Terms

Acquired immunity: immunity obtained in some manner other than by heredity.

Adaptive management: a system of management practices based on clearly identified outcomes, monitoring to determine if management actions are meeting outcomes, and, if not, facilitating management changes that will best ensure outcomes are met or to re-evaluate the outcomes. Adaptive management recognizes that knowledge about natural resource systems is sometimes uncertain and is the preferred method of management in these cases. Specifically, adaptive management is the integration of program design, management, and monitoring to systematically test assumptions to adapt and learn. Adaptation is about taking action to improve the project based on the results of monitoring.

Agglutination: The clumping of cells such as bacteria or red blood cells in the presence of an antibody. The antibody or other molecule binds multiple particles and joins them together, creating a large compound molecule.

Anaphylaxis: an immediate, exaggerated allergic reaction to an antigen.

Antibiotic: a chemical substance produced by microorganisms that can inhibit the growth of or destroy other microorganisms.

Antibody: a protein molecule synthesized on exposure to an infectious agent (i.e., bacteria or virus), which can combine specifically with that antigen.

Antigen: any foreign substance that can bind to specific lymphocyte receptors and so induce an immune response.

Attenuation: the reduction of virulence of an infectious agent.

Bacterium: any of the unicellular prokaryotic microorganisms of the class Schizomycetes, which vary in terms of morphology, oxygen and nutritional requirements, and motility, and may be free-living, saprophytic, or pathogenic in plants or animals.

Ballistic delivery method: delivery through a rifle-like device.

Bio-absorbable projectile: remote delivery device where vaccine is encapsulated into a bullet-like capsule that dissolves in liquid.

Biobullet®: trade name of one type of bio-absorbable projectile.

Bison management zone: an area contiguous to the park where some of all bison may be tolerated for part or all of the year without increasing the risk of brucellosis transmission to domestic livestock.

Bovids: members of the Bovidae family; hoofed, hollow-horned ruminants.

Carrion: dead and putrefying flesh.

Cervid: members of the Cervidae family; even-toed hoofed mammals characterized by the bearing of antlers in the male or in both sexes.

Clinical sign: a sign or symptom of a disease that can only be identified by careful diagnosis with laboratory techniques.

Conjunctiva: a clear mucous membrane consisting of cells and underlying basement membrane that covers the white part of the eye and lines the inside of the eyelids.

Culture-negative: a test result that was unable to detect the organism of focus.

Culture-positive: a test result that clearly identifies an organism of focus.

Culture tests: a method for growing or increasing the abundance of bacterial or viral organisms, then subsequently identifying which organisms are included in the test sample.

Cytokine: one of a diverse group of soluble proteins that have specific roles in host defenses.

Dam: the female parent of a four-legged animal.

Debilitating reaction: individual reaction to a stimulus that causes a crippling injury.

Demography: the science of vital statistics relating to deaths, births, immigration, emigration.

Density dependent: a response, in wildlife populations, characterized to be a result of a high number of individuals within a given area.

Deterministic population model: method of mathematically simulating the processes that occur within a system using defined inputs that do not fluctuate in time and space.

Direct contact transmission: mode of disease transmission requiring individual-to-individual body contact.

Dispersal : movement from one spatial unit to another without return (at least in the short term; Stenseth and Lidicker 1992).

Dose: a prescribed amount of medication.

Ecology: the study of relationships among organisms and their environment.

Efficacious vaccine: a substance containing antigen that effectively stimulates an immune system response.

Efficacy: the capacity for producing a desired result or effect; effectiveness.

Enzootic: affecting or peculiar to animals of a specific geographic area.

Epidemiology: the study of factors and mechanisms involved in the spread of disease within a population.

Epizootic: a disease of sudden onset within an animal population with reasonable probability of infecting humans in close proximity.

Exotic: of foreign origin or character; not native; introduced, but not fully naturalized or acclimatized.

Experimental challenge: deliberate dosing of an infectious pathogen in an experimental environment.

Extracellular pathogens: disease-causing organisms that infect a host within the environment surrounding the cell wall.

Field-strain: a type of pathogen (bacteria or virus) found in the wildland environment.

Foreign cells: cells of an organism that are atypical or uncharacteristic of the organism (e.g., pathogens).

Free-range: allowance of animals to graze or forage for food rather than being confined to a feedlot or a small enclosure.

Gestation: time of pregnancy.

Gold standard test: the best test procedure available for diagnosing diseases.

Greater Yellowstone Ecosystem: the general location where the states of Idaho, Montana, and Wyoming share a boundary; measuring roughly 250 miles north-to-south by 125 miles east-to-west.

Host: a living animal or plant on or in which a parasite lives.

Humoral immune response: a response to foreign antigens carried out by antibodies circulating in the blood.

Immune response: an integrated bodily response to an antigen, especially one mediated by lymphocytes and involving recognition of antigens by specific antibodies or previously sensitized lymphocytes.

Immunity: the ability of an organism to defend itself against infectious agents.

Immunologic response: a bodily defense reaction that recognizes an invading substance (an antigen: such as a bacterium.

Incubation period: in the stages of an infectious disease, the time between initial exposure to the infection and the appearance of signs and symptoms.

Infectious disease: disease caused by infectious agents (bacteria, viruses, fungi, protozoa, and helminthes).

Infectious dose: the quantity of a pathogen that stimulates an infection.

Inoculation: the administration of a vaccine by injection or scratching.

Interferon: a small protein often released from virus-infected cells that binds to adjacent uninfected cells, causing them to produce antiviral proteins that interfere with viral replication.

Interleukins: a cytokine produced by leukocytes.

Interspecies transmission: the passing of a disease pathogen between two species.

Intracellular pathogens: a disease causing organism that operates within the cell walls of host tissues.

Latent disease: a disease characterized by periods of inactivity either before symptoms appear or between attacks.

Lymph node: an organ consisting of many types of cells, and is a part of the lymphatic system. They are found all through the body, and act as filters or traps for foreign particles. They contain white blood cells. Thus they are important in the proper functioning of the immune system.

Lymphatic system: body system, closely associated with the cardiovascular system, that transports lymph in lymphatic vessels through body tissues and organs; performs important functions in host defenses and specific immunity.

Lymphocyte cells (T-cells): a leukocyte (white blood cell) found in large numbers in lymphoid tissues that contribute to specific immunity.

Lyophilization: to freeze-dry blood plasma or other biological substances.

Migration: seasonal, round-trip movements between discrete areas not used at other times of the year (Berger 2004).

Mortality: deaths; death rate.

Mucous membrane: a layer of cells lining all body passages that open to the air, such as the mouth and nasal canal, and having cells and associated glands that secrete mucus (a moist secretion).

Naïve: an individual that has never been exposed to a particular disease.

Natural resistance: ability to fend off a disease simply by the make-up of an organism's genes (i.e., DNA).

Naturally acquired adaptive immunity: defense against a specific disease is acquired sometime after birth, without the intervention or use of man-made products such as vaccines or gamma globulin (blood serum proteins).

Niche: the position or function of an organism in a community of plants and animals.

Parasite: an organism that lives in or on, and at the expense of, another organism, the host.

Parturition: the process of birthing at the end of the pregnancy cycle.

Pathogen: any organism capable of causing disease in its host.

Pathogenesis: the mechanism of a disease.

Pathology: the science of the nature and origin of disease.

Placenta: the organ in the womb to which the fetus is attached.

Polymerize: chemical union of two or more (usually small) molecules to form a new compound.

Prevalence: the number of cases of a disease.

Preferred niche: the life strategy that best suits an individual.

Range expansion: the outward dispersal of animals beyond the limits of the traditional distribution for a population (Gates et al. 2005).

Record of Decision: the resulting decisions document at the end of an environmental impact study.

Remote delivery system: method of delivering a biological product without physically restraining individual animals.

Resistance: the ability of a microorganism to remain unharmed by an antimicrobial agent.

Riparian area: areas that are on or adjacent to rivers and streams; these areas are typically rich in biological diversity (flora and fauna).

Scavenger: an animal that feeds on dead or decaying matter.

Serology: the branch of immunology dealing with laboratory tests to detect antigens and antibodies in blood samples.

Seroprevalence: the proportion of a population that has been infected at present or in the past, and is determined by the presence of antibodies in the blood of individual animals.

Serostatus: the presence or absence of specific antibodies (used to diagnose a particular disease from a blood test). Test results can be seropositive, indicating the presence of antibodies, seronegative, indicating the absence of antibodies, or inconclusive.)

Shed: to give off or out, as to discharge from the body.

Simulation: an imitation or enactment, as of something anticipated or in testing.

Statistical difference: a quantitative difference between two sample populations.

Stochastic model: a method of mathematically simulating the processes that occur within a system using input variables that vary over time. Models are used to learn about system dynamics when some input variables have uncertain values.

Susceptible: capable of being affected.

Target individuals: focal animals (the focus of attention).

Transmission: a passage or transfer, as of a disease from one individual to another.

Undulant fever (also called brucellosis and Malta fever): a zoonosis highly infective for humans, caused by any of several species of *Brucella*.

Ungulates: hoofed mammals, members of the orders Perissodactyla (horses, rhinos, and tapirs) and Artiodactyla (pigs, camels, deer, antelope, cattle, and their kin).

Vaccination: the administration of an antigen (vaccine) to stimulate a protective immune response against an infectious agent.

Vaccine: a suspension of living or inactivated organisms used as an antigen to confer immunity.

Virulence: the degree of intensity of the disease produced by a pathogen.

Virus: a submicroscopic, parasitic, acellular microorganism composed of a nucleic acid (DNA or RNA) core inside a protein coat.

White blood cells: any of various nearly colorless cells of the immune system that circulate mainly in the blood and lymph and participate in defensive reactions to invading microorganisms or foreign particles; comprised of B cells, T cells, macrophages, monocytes, and granulocytes.

Zoonosis: any infectious disease that is transmissible from other animals, both wild and domestic, to humans.

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Appendix A: Yellowstone Bison Population

After bison were nearly extirpated from the GYE in the early 20th century, the population was restored through husbandry, protection, and the reintroduction of bison into the Hayden and Firehole valleys (Meagher 1973). Today, this recovered population inhabits areas that permit the full expression of natural behaviors and ecosystem functioning in ways similar to those of the past, including migration, dispersal, and coexistence with an intact predator community.

Yellowstone bison function in two semi-distinct breeding subpopulations that include the central and northern herds (Meagher 1993, Aune et al. 1998, Taper et al. 2000, Fuller et al. 2007a, Olexa and Gogan 2007). The northern herd congregates in the Lamar Valley and on adjacent plateaus for the breeding season (July 15-August 15). During the remainder of the year, these bison occupy a decreasing elevation gradient along the Yellowstone River drainage, which extends approximately 100 kilometers between Cooke City and the Paradise Valley north of Gardiner, Montana (Houston 1982, Barmore 2003). The northern range is drier and warmer than the rest of the park, with average snow-water equivalents (i.e., mean water content of snow pack) ranging from 29.5 to 2.0 centimeters in the higher and lower elevation portions of the range, respectively (Farnes et al. 1999). Upland grasses comprise the majority of forage in the northern range, followed by sedges (*Carex spp.*) and rushes (*Juncus spp.*; Barmore 2003).

The central herd occupies the central plateau of Yellowstone National Park, extending from the Pelican and Hayden valleys with a maximum elevation of 2,400 meters in the east to the lower elevation and thermally influenced Madison headwaters area in the west. Winters are often severe, with snow water equivalents averaging 35 centimeters and temperatures reaching -42 °C (Meagher 1973, Farnes et al. 1999). This area contains a high proportion of mesic meadows comprised of grasses, sedges, and willows, with upland grasses in drier areas (Craighead et al. 1973). Central herd bison congregate in the Hayden Valley for breeding. Most bison move between the Madison, Firehole, Hayden, and Pelican valleys during the rest of the year. However, some animals travel to the northern portion of the park and commingle with the northern herd before returning to the Hayden Valley for the subsequent breeding season.

Population counts of the central bison breeding herd varied widely during 1995-2008 because bison that left the park in winter were subject to culling and up to about 40% of the total population was removed annually. Counts decreased from 2,593 to 1,399 bison during 1996-1998 and varied between 1,904 and 3,531 animals during 2002-2008. In contrast, population counts of the northern bison breeding herd varied between 455 and 888 during 1995-2004, then increased to 2,070 during 2007. This increase was facilitated by immigration from the central breeding herd and, possibly, decreased competition as numbers of elk occupying the range decreased from approximately 19,000 counted individuals in 1994 to fewer than 7,000 individuals in 2008. Thus, emigration and management culls from the central herd have resulted in a more even distribution of bison numbers between the northern and central breeding herds.

The Yellowstone bison population has been infected with brucellosis since at least 1917 (Tunnicliff and Marsh 1935). The distribution of infected individuals in the population is thought to be uniform, though sampling has been opportunistic for the past 90 years and large samples are only collected at capture pens along the park boundary if bison repeatedly attempt to leave the park during late winter or spring (Gates et al. 2005). The rate of brucellosis exposure has been identified at 40-60% of the population during the past 23 years (Cheville et al. 1998).

Chronic infection with brucellosis affects the demography of Yellowstone bison by influencing survival, pregnancy, and birth rates (Fuller et al. 2007b, Geremia et al. 2009).

Bison density and snow pack severity influence the magnitude of migratory movements outside the park boundaries (Bruggeman et al. 2006, 2007, 2009a, b). Survival probability decreases significantly when the number of bison in the central herd exceeds 2,000-2,500 animals and the number of bison in the northern herd exceeds 1,200; especially during winters with severe snow pack when a large proportion of this breeding group migrates to low-elevation winter ranges near the park boundary. Since management actions that cull bison are the overwhelming source of mortality during these years, brucellosis risk management actions are a significant driver of population demographics (Cheville et al. 1998, Fuller et al. 2007a).

Fecundity analyses have shown that seropositive bison have a reduced probability of becoming pregnant compared to seronegative individuals. In addition, seronegative, reproductively mature bison are highly susceptible to *Brucella*-induced abortions. A study of Yellowstone bison found that 67% (8 of 12) of reproductively mature animals that were initially diagnosed seronegative were not observed with calves during their first and second pregnancies following seroconversion (Geremia et al. 2009). The combined effects on pregnancy and birth rates resulted in lower calf production by seropositive bison across all ages. These effects of brucellosis on the demography of central herd bison are evident in time series data that shows the herd grew at a much slower rate than its biological potential during 1970-2000 (Fuller et al. 2007a, b).

Population genetics play an important role in the management of species, particularly in closed systems such as the range of Yellowstone bison. The primary information important for bison management at Yellowstone National Park is estimating genetic variation within and between subpopulations (e.g., breeding herds). A better understanding of these concepts will provide objective criteria for conservation strategies to apply during boundary culling operations. Reduced genetic variability can have negative consequences for the long-term persistence of populations, and limit the ability of a species to adapt to environmental change. A recent study investigating 54 microsatellite loci in 10 bison herds found relatively high levels of genetic diversity (including total number of alleles, allelic richness, observed heterozygosity, and percent of all bison genome alleles) in the Yellowstone population compared to other populations (Halbert 2003). Yellowstone bison also contribute to the overall genetic diversity of the species due to the presence of four unique alleles found in this population. In addition, Yellowstone bison exhibit no introgression from domestic cattle genes, making the population an important repository of pure bison genetic material (Halbert and Derr 2007).

For long-term conservation of the bison population, managers need to know how implementation of the IBMP could influence bison genetic diversity and the long-term viability of any unique subpopulations. These decisions require knowledge of the existing genetic makeup and influential factors. If the population is structured by geographic area, then non-random removals may influence groups disproportionately and lead to a higher risk of losing unique alleles.

Appendix B: Brucellosis

Brucellosis is a contagious bacterial disease caused by various species of the genus *Brucella* that infects domestic animals, wildlife, and humans worldwide. The principal North American wildlife hosts for *Brucella* spp. are bison and elk (*B. abortus*), caribou (*B. melitensis*), reindeer (*B. suis*), and swine (*B. suis*). In North America, the primary livestock hosts of *Brucella* spp. are cattle (*B. abortus*), goats (*B. melitensis*, Mexico only), swine (*B. suis*), and sheep (*B. ovis*). Brucellosis also occurs in carnivores, including dogs, and is usually caused by *B. canis* (USDI and USDA 2000a, Cheville et al. 1998). *Brucella abortus* is the only species of *Brucella* that has been identified in cattle, bison, elk, and sometimes other wildlife species of the GYE (Cheville et al. 1998, Thorne et al. 1997, Kreeger 2002). Transmission of *B. abortus* among cattle, bison, and elk has occurred in captivity (Flagg 1983, Davis et al. 1990, Cheville et al. 1998).

In ungulates, transmission of *B. abortus* typically occurs through ingestion of live bacteria. The incubation period (i.e., time between exposure and onset of infection) varies widely depending on exposure dose, previous vaccination, species, age, sex, stage of gestation, and susceptibility (Nicoletti and Gilsdorf 1997). Following a brief systemic infection, the organism typically localizes in the udder or lymphatic system and, depending on the stage of gestation, in reproductive tissues. Abortion is the characteristic sign of acute brucellosis. Other signs include retained placenta, infertility, reduced milk production, lameness, and swollen joints. Microscopic lesions may also occur in lymph nodes (Rhyan et al. 1994, Olsen et al. 1997). After pregnancy, the *Brucella* bacteria may become dormant, persisting only within cells of the lymphatic system (Cheville et al. 1998, Galey et al. 2005). Following a dormant period, acute infection may recur during subsequent pregnancy (USDI and USDA 2000a, Galey et al. 2005).

The *Brucella* bacteria are shed in aborted tissues, reproductive tissues, and discharges, especially just prior to, during, or soon after abortion or live birth (Williams et al. 1993, Rhyan et al. 1994). The bacteria may also be shed in milk by lactating adult females (Rhyan and Drew 2002). Some infected cattle, bison, and elk intermittently shed the bacteria throughout their reproductive life. There appears to be no feasible treatment or cure for wild bison and elk infected with *Brucella*. In experimental animals infected with *Brucella*, bacteria remained in their system for many weeks despite antibiotic treatments (Young and Corbel 1989). The only known treatment for brucellosis is through a series of antibiotic doses given routinely for a period of weeks. Some animals may develop immunity and never have the disease. Animals that overcome the clinical signs of brucellosis may develop recurrent infections and be a source of exposure and possible infection for other animals. Some animals may completely clear the bacterium. Some individual cattle have a natural resistance to brucellosis and this trait may be heritable (Templeton et al. 1988). Natural resistance may also occur in bison (Derr et al. 2002).

In humans, brucellosis is known as undulant fever. Though insidious (i.e., slow, subtle onset), undulant fever is rarely fatal. Human brucellosis in North America may be caused by *B. melitensis* in northern Canada and Mexico, *B. suis* in the southeastern United States, or *B. abortus* in the GYE. Transmission to humans is through ingestion, contact with mucous membranes (e.g., eyes), through an open wound, or by direct contact with skin (Young and Corbel 1989). Infected bison and elk in the GYE are a very minor health risk for people. Those who are most susceptible either improperly handle animal carcasses or may be exposed to birth tissues. The risk is greatest when handling infected females during the last half of pregnancy.

With progress toward eradication of brucellosis in livestock and pasteurization of milk, the national occurrence of undulant fever in humans from all *Brucella* spp. has decreased from 6,500 reported cases in 1940 to 70 cases in 1994. There have been 139 cases of undulant fever in Wyoming since 1929 and during 1995-2005 there were five confirmed cases reported to the Wyoming Department of Health (Snow 2005). In Idaho, there were 17 confirmed cases of undulant fever reported to the Idaho Department of Health and Welfare from 1980 to 2003. However, there have been no known cases of human undulant fever in Wyoming or Idaho attributed to wildlife. In Montana, there have been two confirmed cases of hunters contracting undulant fever from elk (Greater Yellowstone Interagency Brucellosis Committee 1997). The last confirmed case was in 1995 (Zanto 2005).

B.1 Diagnostic Tests

The presence of antibodies is used as an indication of past or present infection. In wildlife, serology is used primarily to determine disease exposure on a population basis. There is no single test to specifically identify those live animals currently capable of transmitting brucellosis. Multiple serologic and bacteriologic culture tests of milk, lymphatic tissues, uterine discharges, and fetal tissues over time are the only reliable methods to determine infection in live animals (Nielsen and Duncan 1990, Cheville et al. 1998, USDI and USDA 2000a, Thorne 2001). Some animals may lack antibodies but still be infected, especially those incubating the bacteria. In contrast, antibodies may be present in an animal from which the bacteria have not been cultured. An animal with natural resistance to the *Brucella* organism that has been challenged with *B. abortus* will generally experience a short-lived antibody response. Tissues collected from these animals will be culture-negative, supporting their resistance to infection. A culture test that is negative does not necessarily mean that animal is not infected.

The gold standard test for identifying the bacteria is the culture test. However, killing suspect animals is generally necessary to obtain adequate samples for bacteriologic culture. Interpretation of culture results is difficult because the ability to isolate the bacteria varies with the location and abundance of *B. abortus* in the animal. A positive culture of *Brucella* organisms from tissue or blood is a definitive indication of infection. However, the *Brucella* organism may not always have been recovered even though it is present. Also, it is not possible to determine with certainty the risk of bacterial transmission based on the results of these standard serologic and culture tests. Within a herd, the number of animals capable of transmitting the bacteria is generally lower than the number of animals with positive blood test results. For regulatory purposes, a herd with non-vaccinated, seropositive animals is considered infected.

B.2 Infection Rate in Yellowstone Bison

The relationship between serologic and culture results and the probability of individual bison being infectious is complex. Information gathered on Yellowstone bison since 1984 indicates that 40-60% of the population may be serologically positive for brucellosis antibodies (Figure B1). In addition, studies attempting to culture *B. abortus* from Yellowstone and Jackson bison indicate that seropositive bison can be expected to culture positive for this bacterium at rates reaching 46% (Table B1). Animals that culture positive are more likely to be infectious and shed live bacteria (Cheville et al. 1998). Two studies in particular have shown that seropositive bison that are also culture positive are more likely to be in young age classes (≤5-years-old), constituting the highest risk age groups for shedding *B. abortus* (Meyer and Meagher 1995, Roffe et al. 1999). The quantity of *Brucella* organisms shed and the number of organisms that comprise an infectious dose at any particular time are both variable based on the vaccination history of the individual and the body condition at the time of shedding (Thorne 2001).

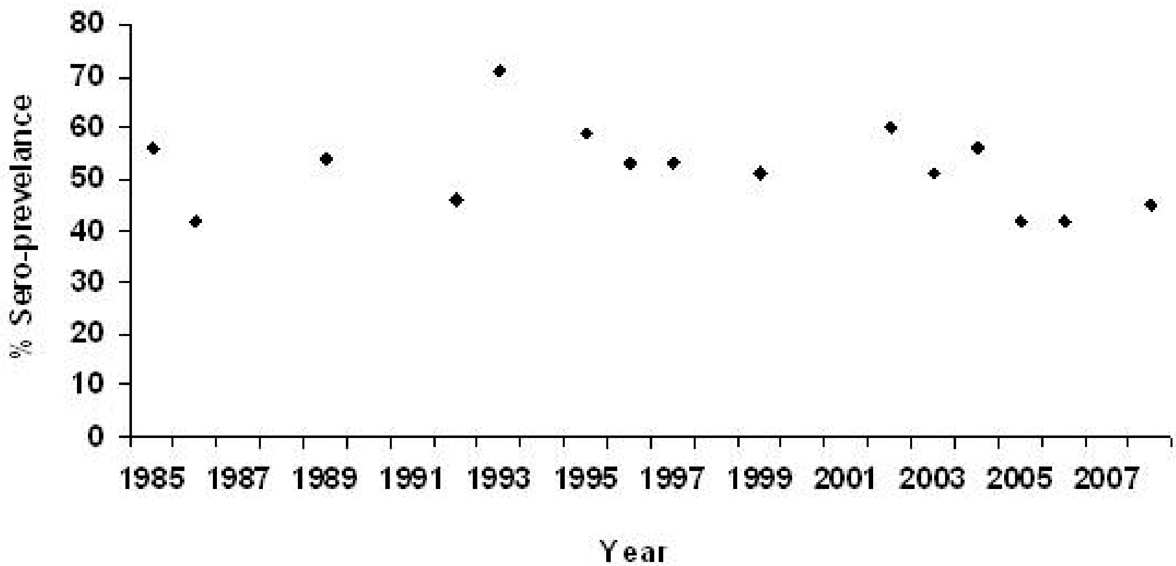

Figure B1. Annual seroprevalence in Yellowstone bison, 1984-2008.

Table B1. Percent of seropositive bison that culture positive for *Brucella abortus* bacteria

Percent of seropositive bison samples that were culture positive for *B. abortus*	Reference
46	Roffe et al. (1999)
27	Philo and Edwards (2002)
36	Williams et al. (1993)
25	Meyer and Meagher (1995)

B.3 Epidemiology of Brucellosis

Epidemiology, or the spread of disease within a population, of brucellosis in wildlife populations is influenced by a variety of environmental and management-related parameters, the susceptibility of the host to infection, and the magnitude of the exposure encountered by naïve individuals (Williams et al. 1997, Thorne 2001). While the route of exposure is primarily through mucous membrane contact (Cheville et al. 1998, Thorne 2001), the magnitude of exposure is correlated with the number of aborted pregnancies within chronically infected populations (Crawford et al. 1990, Cheville et al. 1998, Gross et al. 2002).

The primary mechanism for transmission of *B. abortus* in cattle is well understood. Typically, transmission occurs when susceptible animals come into direct contact with contaminated aborted fetuses, birth membranes, uterine fluids, or vaginal discharges from infectious animals. Ingestion of contaminated material is the primary route of infection. A female calf born to an infected dam (female parent) can also become infected in-utero, but will not manifest the disease until it has either aborted or calved. Infected females typically abort their first pregnancy following infection, which usually occurs during the third trimester. Thereafter, the bacteria usually localizes in lymph nodes surrounding reproductive organs and the udder. Bacteria are shed in milk, aborted tissues, birth membranes, and discharges from the female reproductive tract just prior to, during, or after birth or abortion.

Transmission of *B. abortus* in wild ungulates is less understood than in livestock settings. Brucellosis is primarily maintained within the bison population through contact with bacteria shed by infected adult females at the time of aborted pregnancies or successful live births.

B.4 Pathogenesis in Bison

The processes associated with exposure, infection, and shedding of *B. abortus* in bison are complex. *Brucella* organisms are intracellular pathogens whose ultimate goal is to propagate in their preferred niche, the interiors of individual cells (Grovel and Moreno 2002). Once *Brucella* organisms are introduced to a susceptible bison by direct contact with a mucous membrane, specialized white blood cells from the bison's immune system ingest the bacteria. The ability of *B. abortus* to survive within specific white blood cells of the host is an important aspect of infection. This allows the bacteria to be protected from the host organism's defense mechanisms that inhibit the growth in numbers of *B. abortus.* The capability of the *Brucella* pathogen to replicate intracellularly is a crucial component regarding initial incubation of the disease, along with latency effects that perpetuate the chronic infection of the Yellowstone bison population (Nicoletti and Gilsdorf 1997).

Brucella abortus organisms have the capacity for long-term survival at relatively low numbers within the mammalian host. Bacteria are recognized as foreign materials and ingested by white blood cells, then transported to tissues in the lymphoid system where they can persist within lymph nodes and the spleen. Here they may reproduce quickly when activated by hormones during the final trimester of pregnancy. In the chronically infected Yellowstone bison population, the disease brucellosis is maintained by the bacteria's ability to multiply in the female reproductive tract. That ability is expressed foremost in the membranes and fluids associated with the developing fetus, thereby changing low-risk females into a high risk for shedding live bacteria during the final stage of pregnancy (Cheville et al. 1998).

The detailed processes leading to an aborted pregnancy after mid-gestation are not clear, but *Brucella* organisms preferentially replicate in placental cells during the middle and late stages of gestation. Individual animals appear most vulnerable to *B. abortus* infection at this time of life. During this period, *Brucella* probably induces the synthesis of hormones that may be used as growth factors for the bacteria and create hormonal conditions that mimic those at the initiation of parturition (Grovel and Moreno 2002). This results in abortions and bison born prematurely. During these events, the aborted fetus or underdeveloped calf are highly infectious due to a large number of *B. abortus* organisms in the placenta and birth fluids.

Susceptible individuals become infected through interaction with birthing materials (amniotic fluids and placenta) and the newborn calf or fetus. Normal birth events as well as aborted pregnancies can draw attention by other bison (Aune et al. 1998). An infectious event in the early portion of the parturition period may draw increased attention resulting in greater numbers of bison exposed to the shed bacteria and a greater probability of susceptible pregnant bison becoming infected and shedding bacteria during the same parturition period. The large amount of *B. abortus* bacteria shed during these events, combined with the strong attractant effect of expelled fetal membranes, are the two factors that drive transmission of *B. abortus* and ensure perpetuation of the disease (Cheville et al. 1998).

B.5 Immune Response to Infection

The evolutionary success of the *Brucella* pathogen lies in its adaptive ability to hide from the host's immune system. The immune system consists of a network of cells, tissues, and organs working together to defend the body against attacks by "foreign" invaders. A key component of the immune system is its capability to distinguish between normal cells of the host and foreign cells. Antigens are proteins on the surface of an invader (e.g., bacteria) which identify it as an invader and trigger an immune response in the host. During this response, the host produces an antibody that binds to the antigen and marks the bacteria to be destroyed by the host's immune system. The ability of *B. abortus* to persist in the white blood cells of the host allows the bacteria to avoid being marked and destroyed. This phenomenon of intracellular persistence has been suggested as an explanation for the chronicity of brucellosis, as well as relapses following treatment (Braude 1951a, b; Spink 1952). The intracellular environment sustains extensive replication, allowing growth in the number of bacteria and subsequent transmission to new hosts frequently achieved through the heavily infected tissues and fluids associated with the developing fetus (Grovel and Moreno 2002).

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Appendix C: Vaccination

C.1 Vaccination Theory—Why Vaccinate?

Long before causes of disease and the processes of recovery were known, observers discovered that individuals who recovered from a disease appeared more resistant to the same disease during a second exposure (Maybury Okonek and Peters 2004). It is now known that the immune system is composed of a variety of cells (white blood cells are the most common) and organs (spleen and thymus) that provide an animal's adaptive defense mechanisms against infection and disease (Black 2005). Animals can attain immunity to a disease in a variety of ways.

Vaccines, when administered to previously uninfected hosts, mimic the natural infection process and, thus, teach the immune system how to react to antigens. Macrophages in the body (cells designed specifically for "eating" foreign substances) cannot distinguish vaccines from the natural infectious bacteria and consume the invading cells. The macrophages save the antigen from the surface of the invading cells and present them to specialized white blood cells (lymphocytes) in the lymph nodes. These T and B cells in turn signal the system to (1) activate more lymphocytes, (2) actively attack and destroy infected cells, and (3) secrete antibodies to bind with the antigen of the invading cells. Antibodies attack the foreign substances that have yet to invade cells within the body and cause them to become non-functional. The antibodies also signal macrophages to eat the antibody/antigen complex.

Each antibody fits with only one antigen so the immune system maintains a supply of millions of different antibodies. While the infectious bacteria is replicating within the body of the host, the immune system is gearing up by producing many of the specialized cells described here to overcome the infectious invading cells. Gradually the infection disappears. Once the infection is eliminated some of the B and T cells are converted to memory cells. These cells will circulate in the body and allow the system to respond to subsequent infectious exposure more rapidly.

The mock infection provided by the vaccine will clear the immune system, leaving behind a supply of memory cells that enable a host to fend against subsequent exposure to the natural strain of bacteria more effectively.

The spread of diseases requires infected and susceptible individuals. When the number of susceptible individuals drops to a very low level, a disease should disappear. Vaccination of susceptible individuals provides them with an acquired immunity without exposing them to the full effects of the natural infection process.

When actively vaccinating populations against diseases, a vaccine is used that is either a modified or weakened version of the original pathogen. The higher the proportion of vaccinated individuals in a population, the sooner the disease is expected to disappear.

Herd vaccination is a process of reducing the proportion of susceptible individuals in a population to very low numbers until the exposure probability disappears. In latent diseases like brucellosis, vaccination requires diligence until the proportion of recovered individuals reaches very close to zero. An immune system response by a vaccinated bison would require exposure to a larger amount of *B. abortus* than a non-vaccinate to stimulate an infection. Consequently, vaccinates are expected to shed much less infectious bacteria upon exposure to the same dose as a non-vaccinate; thus reducing the amount of infectious material being shed. While birthing materials (amniotic fluid, placenta, umbilical cord, live or stillborn fetus) are the primary mode of disease transmission, a decrease in the rate of aborting pregnancies would result in a decrease in the rate of disease transmission among bison.

Vaccines rarely provide 100% protection from infectious diseases (Gandon et al. 2001). When disease-causing organisms invade the interior of individual cells, an effective immune system response, while more complicated, leads to an acquired immunity as described above. However, immunity to an intracellular organism like *B. abortus* requires a reaction by specialized lymphocyte cells (T-cells) that result in a cell-mediated reaction. Cell-mediated immune responses disrupt *B. abortus's* ability to replicate, make copies of itself within host cells, and prevent the pathogen from invading new cells. This type of acquired immunity brings with it a possibility of latent infection, whereby an animal may not be resistant to active infection for the rest of its life.

C.2 Vaccination of Wildlife

Disease is a natural part of ecological systems and has occurred in wildlife species since the Paleozoic era. The evolution of cervids and bovids during the Miocene epoch has led to the belief that these hosts coevolved together in ways that reflect the other's evolution (Aguirre and Starkey 1994). Studies have shown that natural diseases can exist within the wildlife population and do not always negatively affect a population (Schubert et al. 1998, Grinder and Krausman 2001, Hudson et al. 2002, Hanni et al. 2003). However, exotic (i.e., non-native) diseases have the potential to erupt quickly within a population and negatively affect natural behavior and ecosystem functions. Exotic diseases are considered a threat to some populations, as well as a public health and safety risk in some cases. Therefore, human intervention is necessary where feasible (Barlow 1991, Aguirre and Starkey 1994, McNeil et al. 2000, Corner et al. 2001, Delahay et al. 2003, Turnbull et al. 2004).

The concept of wildlife vaccination dates back to the early 1970s when baits containing rabies vaccine were distributed to control this disease in red foxes. Since that time, vaccines have been distributed to many species in many countries (Table C1).

Vaccines are becoming a recognized, low risk method for effectively reducing transmission risk of diseases. Barlow (1996) suggests that vaccination is a superior method of managing disease over culling of infected individuals when the contact rate of disease is not density-dependent and the host has a low death rate combined with a high rate of population increase. Buddle et al. (2000) and Plumb et al. (2007), however, noted that vaccination may or may not be an acceptable method for controlling and subsequently eradicating animal diseases, including intracellular pathogens. If and when implemented, wildlife vaccination requires a combination of novel management strategies to address the disease vector and public education to balance conservation, economic, and public health issues (Plumb et al. 2007).

Table C1. Wildlife species vaccinated for a range of animal disease through the world

Species	Disease delivery route	Country	Citation
Fox	rabies (oral)	United States	Centers for Disease Control (2005)
Racoons	rabies (oral)	United States	Hable et al. (1991)
Brushtail possum	tuberculosis (oral)	New Zealand	Skinner et al. (2005)
Brushtail possum	tuberculosis (aerosol)	New Zealand	Corner et al. (2001)
Mongoose	rabies (oral)	West Indies	Creekmore et al. (1994)
Elk	brucellosis (ballistic)	United States	Herriges et al. (1989)
Raccoon	canine distemper (oral)	Canada	Schubert et al. (1998)
Badger	tuberculosis (oral)	United Kingdom	Delahay et al. (2003)
Cheetah	anthrax (ballistic)	Namibia, Africa	Turnbull et al. (2004)
Black rhinoceros	anthrax (ballistic)	Namibia, Africa	Turnbull et al. (2004)
Bighorn sheep	pasteurellosis (ballistic)	United States	McNeil et al. (2000)

In accordance with Chapter 4 of NPS Management Policies 2006 (NPS 2006), the NPS may intervene to manage populations of native species only when such interventions will not cause unacceptable impacts to the population or to other components and processes of the ecosystem. Vaccination of wildlife with effective and low risk vaccines would be considered intervention that does not cause unacceptable impacts to the population or ecosystem since the aim of the program is to cause a decline in abundance of an exotic or non-native species (*B. abortus*). Some factors that support implementing a vaccination program are:

- Vaccination to prevent disease or reduce transmission is less expensive than to treat individuals that become infected with the disease.
- Immunity or resistance acquired through vaccination is less risky, in general, than managing a naturally infected population because the illness in vaccinates is less contagious to other susceptible individuals that are naive to the disease.
- Vaccinates will be contagious for less time than non-vaccinates when they are naturally exposed to the disease pathogen.
- Vaccinates will shed less contagion than non-vaccinates when they are naturally exposed to the disease pathogen.
- The higher the proportion of the population that has an acquired immunity through vaccination, the less violent the infectious outbreaks will be because fewer individuals will be highly susceptible. High herd immunity leads to a low probability of infectious events that spread the disease to numerous animals (i.e., “super-spreader” events).

The IBMP includes definitions of safety (i.e., low risk) and efficacy of vaccines for use in calves and adults, a definition of safety for non-target species, and summaries of recent research (USDI and USDA 2000a). In the ROD for the IBMP, the partner agencies made the decision to vaccinate bison that occupy Zone 2 Management Areas when a vaccine was shown to be low risk. Two vaccines, Strain 19 and Strain RB51 (SRB51), were developed to prevent brucellosis in cattle and have been used in bison and elk. Strain 19 is no longer available commercially, but stocks of this vaccine can be found in research laboratories and formulated for field vaccination programs. Such is the case in Wyoming where this vaccine is currently being used to vaccinate elk in the northwestern portion of the state on state feed grounds. Strain RB51 has replaced S19 as the required vaccine for cattle in the United States. It is genetically stable in bison and does not revert to virulent forms after growth in vivo (Cheville et al. 1998). Strain RB51 has been shown experimentally to cause endometritis and placentitis that result in abortion in pregnant bison vaccinated during the third trimester of pregnancy (Palmer et al. 1996). Of eight pregnant bison females given SRB51, two females aborted 68 and 107 days after vaccination (Palmer et al. 1996).

Modern techniques in DNA sequencing and gene splicing have led to advances in vaccine development. For example, *B. abortus* SRB51 can be modified to produce a new strain capable of use in a vaccine for the treatment of brucellosis (Boyle et al. 2000). These types of advances will most likely lead to new vaccines that replace live vaccines with lower risk vaccines for human handling and for non-target species.

A low risk vaccine has two components: protein or DNA derivative of disease and an effective delivery system (Brake 2003). Oral delivery is the most common method for vaccine delivery to wildlife. However, delivery methods are evolving and systematic improvements in delivery mechanisms are expected as more information is available about wildlife ecology and disease epidemiology (Aune et al. 2002). Methods for remote delivery of vaccine do not involve direct contact with humans. In general, these methods consist of, but are not limited to, compressed air-powered rifles firing biobullets or darts, bait containing vaccine, and aerosol sprays mixed with feed. The two later methods are not currently available techniques for delivery of brucellosis vaccines.

Appendix D: Safety and Efficacy Criteria for Bison Vaccines Against Brucellosis

D.1 Protocol for Evaluating Safety and Efficacy of a Wildlife Vaccine against Brucellosis in the Greater Yellowstone Area

Prepared for the Greater Yellowstone Interagency Brucellosis Committee

The purpose of this protocol is to establish guidelines for the development and evaluation of new brucellosis vaccines to be used in free-ranging elk (*Cervus elaphus*) and bison (*Bison bison*) inhabiting the Greater Yellowstone Area. This protocol is not intended to evaluate current vaccination programs being applied to these species. The recommendations for the following criteria regarding efficacy and safety are based on the assumption that any brucellosis vaccine evaluated by these criteria would have defined dosage, route of administration, and age restrictions for any application of the vaccine. The vaccine strain will demonstrate stable characteristics following in vitro and in vivo passage. Efficacy evaluations within the principal species should include animals of minimal recommended age, at the minimally recommended dosage and administered in accordance with recommendations. For safety evaluations within the principal species, animals should be of minimal recommended age, at the maximal recommended dosage, and administered in accordance with recommendations. The assumption is also made that the criteria for approval of a vaccine as safe will be the same in both male and female animals in the targeted population. For the purposes of this paper, the definition of a calf will be a bison or elk of less than 12 months of age. Restrictions on use (e.g., sex, age) may be applied without rejection of the vaccine in total. For example, limit use to females because of adverse reactions in males.

D.2 Calfhood Vaccination

D.2.1 Safety

To be defined as safe, a vaccine would not have any clinical effects that would increase predation or decrease survivability. However, adverse clinical effects such as listlessness, anorexia, depression, and arthritis that are transient and minimal with no long-term effects on survival may be acceptable. There should be no statistical difference between vaccinates and controls on these factors. A safe calfhood vaccine will not be shed from a vaccinate prior to parturition. The vaccine strain will not persist to the first calving in 95% or greater of the vaccinated individuals, or persistence of the vaccine strain will not be associated with a significant reduction in the survivability (i.e., no pathology) or the reproductive potential of the individual (i.e., repeated fetal loss, infected calves, or decreased fertility). There should be no statistical difference between vaccinates and controls on these factors.

D.2.2 Efficacy

To be defined as efficacious in females, a vaccine must induce statistically greater protection against fetal loss, infected calves, or infection in pregnant vaccinates after experimental challenge when compared to non-vaccinated animals in the same experiment. Infection is defined as either number of colony-forming units per gram of tissue and/or number of infected tissues. Use of model estimations must indicate that the vaccine, when used alone without other management influence, will reduce the prevalence of brucellosis in the targeted wildlife population. Experiments will need to be conducted to evaluate the duration of immunity of the vaccine but these experiments will not be required for initiation of use of the vaccine if all other safety and efficacy criteria are met. A vaccine should provide long-term immunity and/or be able to be safely boosted during the life of the animal.

D.3 Adult Vaccination

D.3.1 Safety

A safe vaccine will not induce significant reductions in survivability or reproductive efficiency as statistically demonstrated in clinical trials. A safe vaccine will not cause a significant reduction in recruitment in the population of the target species.

D.3.2 Efficacy

A vaccine will be determined to be efficacious if it induces statistically greater protection in vaccinates against fetal loss, infected calves, or infection after experimental challenge when compared to non-vaccinated animals in the same experiment. In addition, modeling must indicate that the vaccine, when used alone without other management influence, will reduce the prevalence of brucellosis in the targeted wildlife population.

D.3.3 Other

A major advantage of any vaccine would be the ability to differentiate vaccinates from animals infected with *Brucella* field strains either by a serologic test or by alternative methods.

D.4 Nontarget Species

A vaccine candidate cannot cause deleterious effects on the short-term survivability of representative ungulates, rodents, carnivores or avian species under experimental conditions. Candidate species that should be strongly considered for evaluation include: moose, bighorn sheep, antelope, mule deer, coyotes, wolves, ravens, microtus, peromyscus, and ground squirrels. Other species could be added if scientific data supports their inclusion.

—Adopted by the

Greater Yellowstone Interagency Brucellosis Committee

May 1998

Appendix E: Compliance with Federal or State Regulations

This appendix describes key pieces of legislation that form the legal context for development of the EIS. These pieces of legislation have guided development of this document and will continue to guide implementation following a Record of Decision.

E.1 National Park Service Enabling Legislation

E.1.1 16 U.S.C., sec.22 (17Stat.32), Mar. 1, 1872

This Law established Yellowstone National Park and preserved the watershed of the Yellowstone River "for the benefit and enjoyment of the people." Under this law, the land has been reserved and withdrawn from settlement, occupancy, or sale, and dedicated as a public park or pleasuring ground. Congress further directed the preservation of natural resources from "injury or spoliation."

E.1.2 National Park Service Organic Act, PL 64-235, 16 USC §1 et seq., August 25, 1916

Congress created the NPS with this Act, then reaffirmed and amended the Act in 1970 and 1978 to establish a broad framework of policy for the administration of national parks: "… to promote and regulate the use of the … national parks … which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."

E.1.3 General Authorities Act of 1970, 16 USC 1a-1-1a-8, 84 Stat. 825, PL 91-383

The purpose of this Act was to include all areas administered by the NPS into one system and clarify the authorities applicable to the system.

E.1.4 Redwood National Park Act, 16 USC 79a-79q, 82 Stat. 931, PL 90-545

Passed in 1978,the purpose of this Act was to amend the General Authorities Act of 1970, reasserting that system-wide there is a "high standard of protection" prescribed by Congress for the "common benefit of all the people of the United States." This Act recognized that ecological processes cross park boundaries and activities proposed on lands adjacent to the national parks may affect the ability to preserve park resources. Conversely, NPS activities may affect external resources and values. Recognizing that parks are integral parts of larger systems, the Act directed superintendents to work cooperatively with others to "anticipate, avoid, and resolve potential conflicts."

E.2 General Legislation and Regulations

E.2.1 National Environmental Policy Act, Public Law 91-190, 83 Stat. 852, 42 USC §4341 et seq.

Passed in 1969, the NEPA process is intended to help public officials make decisions that are based on understanding environmental consequences of proposed actions. Federal actions should protect, restore, and enhance the environment. Regulations implementing NEPA are set forth by the Council on Environmental Quality (see next entry).

E.2.2 Council on Environmental Quality Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act (40 CFR Parts 1500-1508)

The Council of Environmental Quality regulations for implementing NEPA established the process by which federal agencies fulfill their obligations under the NEPA process. The regulations contain the requirements for environmental assessments and environmental impact statements that document the NEPA process. These regulations also define the terms cumulative impact, mitigation, and "significantly" to ensure consistent application in environmental documents. This EIS was prepared as directed in the Council of Environmental Quality regulations.

E.2.3 Wilderness Act of 1964, Public Law 88-577, 78 Stat. 890, 16 USC §§1131-1136

The Wilderness Act directed the Secretary of the Interior, within 10 years, to (1) review every roadless area of 5,000 acres (2,023 ha) or more and every roadless island (regardless of size) within National Wildlife Refuge and National Park Systems, and (2) recommend to the President the suitability of each such area or island for inclusion in the National Wilderness Preservation System, with final decisions made by Congress. The Secretary of Agriculture was directed to study and recommend suitable areas in the National Forest System. The Act provides criteria for determining suitability and establishes restrictions on activities that can be undertaken on a designated area.

E.2.4 Freedom of Information Act of 1966, Public Law 89-487, 80 Stat. 250, 5 USC §552

The Freedom of Information Act grants United States citizens the right to access government information upon request. This Act only applies to records of the Executive Branch of the Federal government. The Act gives members of the public the right to access any federal record unless the information in those records is protected by one of nine exemptions and there is a sound legal basis to withhold them. A member of the public obtains records by submitting a written request to the appropriate department.

E.2.5 Omnibus Management Act of 1998, PL 105-391, 16 USC 5901-6011

The National Parks Omnibus Management Act of 1998 reinforces the mandate of the Organic Act to preserve park resources in a condition that will maintain them for future generations to observe and enjoy. In managing parks to preserve naturally evolving ecosystems, and in accordance with requirements of the Act, the NPS uses the findings of science and the analyses of scientifically trained resource specialists in decision-making.

E.3 Natural Resources Legislation

E.3.1 Migratory Bird Treaty Act of 1918, 40 Stat. 755, 16 USC §§703-712

The original 1918 statute implemented the 1916 convention between the United States and Great Britain (for Canada) for the protection of migratory birds. Later amendments implemented treaties between the United States and Mexico, Japan, and current day Russia, respectively. Specific provisions in the statute include an establishment of a federal prohibition, unless permitted by regulations, to "pursue, hunt, take, capture, kill, attempt to take, capture or kill, possess, offer for sale, sell, offer to purchase, purchase, deliver for shipment, ship, cause to be shipped, deliver for transportation, transport, cause to be transported, carry, or cause to be carried by any means whatever, receive for shipment, transportation or carriage, or export, at any time, or in any manner, any migratory bird, included in the terms of this convention … for the protection of migratory birds … or any part, nest, or egg of any such bird" (16 U.S.C. 703). The statute also prohibits the interstate or international transport of a migratory bird, part of bird, nest of bird, or egg of bird that was taken or killed in violation of the law of the district where it was taken from or killed.

E.3.2 Bald Eagle Protection Act of 1940, 54 Stat. 250, 16 U.S.C. 668-668d

This law provides for the protection of the bald eagle and the golden eagle by prohibiting, except under certain specified conditions, the taking, possession, and commerce of such birds. The 1972 amendments increased penalties for violating provisions of the Act or regulations issued pursuant thereto and strengthened other enforcement measures. The 1978 amendment authorizes the Secretary of the Interior to permit the taking of golden eagle nests that interfere with resource development or recovery operations. A 1994 Memorandum from President Clinton to the heads of Executive Agencies and Departments sets out the policy concerning collection and distribution of eagle feathers for American Indian religious purposes.

E.3.3 Endangered Species Act of 1973, as amended, Public Law 93-205, 87 Stat. 884, 16 USC §1531 et seq.

The Endangered Species Act protects threatened and endangered species, as listed by the USFWS, from unauthorized take and directs federal agencies to ensure that their actions do not jeopardize the continued existence of these species. Section 7 of the Act defines federal agency responsibilities for consultation with the USFWS and requires preparation of a biological assessment to identify any threatened or endangered species that is likely to be affected by the proposed action. The NPS consulted with the USFWS during the planning process.

E.4 Cultural Resources Legislation

E.4.1 Antiquities Act of 1906, PL 59-209, 34 Stat. 225, 16 USC §432, and 43 CFR 3

This Act provides for the protection of historic or prehistoric remains, "or any antiquity," on federal lands. It protects historic monuments and ruins on public lands. It was superseded by the Archeological Resources Protection Act of 1979 as an alternative federal tool for prosecution of antiquities violations in the National Park System.

E.4.2 National Historic Preservation Act of 1966, as amended, Public Law 89-665, 80 Stat. 915, 16 USC§470 et seq., and 36 CFR 18, 60, 61, 63, 68, 79, 800:

The National Historic Preservation Act requires agencies to take into account the effects of their actions on properties listed in or eligible for listing in the National Register of Historic Places. The Advisory Council on Historic Preservation has developed implementing regulations (36 CFR 800), which allow agencies to develop agreements for consideration of these historic properties.

E.4.3 Archeological Resources Protection Act of 1979, Public Law 96-95, 93 Stat. 712, 16 USC §470aa et seq., 43 CFR 7 (subparts A and B) and 36 CFR

This Act secures the protection of archeological resources on public or Indian lands and fosters increased cooperation and exchange of information between private, government, and the professional community to facilitate the enforcement and education of present and future generations. It regulates excavation and collection on public and Indian lands. The Act requires notification of Indian tribes who may consider a site of religious or cultural importance prior to issuing a permit. It was amended in 1988 to require the development of plans for surveying public lands for archeological resources and systems for reporting incidents of suspected violations.

E.4.4 American Indian Religious Freedom Act, Public Law 95-341, 92 Stat. 469, 42 USC §1996

This Act declares policy to protect and preserve the inherent and constitutional right of the American Indian, Eskimo, Aleut, and Native Hawaiian people to believe, express, and exercise their traditional religions. It provides that religious concerns should be accommodated or addressed under NEPA or other appropriate statutes.

E.4.5 Native American Grave Protection and Repatriation Act, Public Law 101-601, 104 Stat. 3049, 25 USC §3001-3013

This Act assigns ownership or control of human remains, funerary objects, sacred objects, and objects of cultural patrimony that are excavated or discovered on federal lands or tribal lands to lineal descendants or culturally affiliated American Indian groups.

E.5 Executive Orders

E.5.1 Executive Order 13007 Sacred Sites; Executive Order 13175: Consultation and coordination with Indian Tribal governments; Memorandum on Government to Government relations with American Indian Tribal Governments

These orders direct federal land managing agencies to seek open and meaningful exchange of knowledge and ideas with American Indian tribal governments to enhance the understanding of park resources and values and the policies and plans that affect them. In addition, parks must accommodate access to, and ceremonial use of, Indian sacred sites by Indian religious practitioners and avoid adverse effects to such sites.

E.5.2 Executive Order 13112: Invasive Species

This order directs federal agencies to not authorize, fund, or carry out actions they believe are likely to cause or promote the introduction or spread of invasive species.

E.6 National Park Service—Director's Orders

Director's orders provide guidance for implementing specific issues described in NPS policy. Copies of orders may be obtained by accessing the NPS web site at www.nps.gov/refdesk/DOrders/. Director's orders that are relevant to this planning process include the directives system (1), park planning (2), conservation planning and environmental impact analysis (12), tourism (17), agreements (20), cultural resource management (28), wilderness preservation and management (41), occupational safety and health (50B), relationships with American Indians and Alaska Natives (71-A), substances used for wildlife management and research (77-4), integrated pest management (77-7), endangered species (77-8), public health NPS Guidelines (83), and conflict resolution (93).

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Appendix F: Cost Estimates for Implementing Each Alternative

Cost estimates for implementing remote delivery vaccination inside Yellowstone National Park are based on an implementation strategy that assumes the team will attempt to deliver vaccine to as many vaccination eligible bison as possible from mid-September through November. A second, but less comprehensive, delivery season would occur in March through May to provide a second vaccine dose to yearling and two-year-old females. The effectiveness of the vaccination program is contingent on delivery of vaccine to a high proportion of unique vaccine eligible individuals prior to exposure and infection by the field strain bacteria (Treanor et al. 2007a, b). Marking of individuals on a short-term basis (e.g., paint spot) will likely be necessary to track the number of different individuals receiving a remote vaccination attempt.

A variety of study parameters will be necessary to ensure the monitoring effort can correctly assess whether the vaccination program is producing a decrease in brucellosis infection (White et al. 2008). Marking individual bison that are handled either at the Stephens Creek capture facility, Duck Creek capture facility, or through chemical immobilization in the field will be necessary to evaluate population seroprevalence, incidence of infection, rates of seroconversion, and persistence in shedding of the bacteria.

Monitoring the effectiveness of the proposed vaccination program is complicated and will be a significant challenge to conduct. The ability to detect a change in seroprevalence is a function of the (1) amount of decrease in seroprevalence, (2) shape of the seroprevalence decrease curve, and (3) the sample sizes used for estimating seroprevalence (Ebinger and Cross 2008). The ranges of possibility for the amount of decrease in seroprevalence and for the shape of the decrease curve are relatively unknown. Attempting to detect a change in seroprevalence from monitoring data involves multiple statistical tests over time. The probability of detecting a difference between the baseline and some future point in time increases as you increase the number of individuals periodically tested (Ebinger and Cross 2008). An annual testing increment of fewer than 200 individuals provides a poor probability of detecting a decrease in seroprevalence to below 40%. In addition, sampling at much greater numbers than 250 individuals does not significantly improve the probability of precision in detecting a change in seroprevalence.

Goals—Deliver vaccine to as many vaccine eligible bison as possible to achieve a delivery proportion of greater than 50%. Target calves and yearling females as priorities in the autumn delivery period and include adult females, where feasible; then follow-up with additional delivery to yearling and two-year old females in May and June. As the program evolves and seroprevalence in young adults decreases, vaccination of adult females will increase in priority.

F.1 Assumptions Used to Make Projections

1. Primary field season to deliver vaccine will require 18 weeks of work.
2. Field crews will approach groups and deliver vaccine to eligible bison and mark each vaccinated animal with a paint spot using paint gun either attached to biobullet rifle or by

separate person delivering the mark. Crews will repeatedly contact groups of bison until the end of the vaccination season to deliver vaccine to as many eligible animals as possible.

3. During an 18-week delivery program, the field crews will not be able to vaccinate every eligible bison due to (1) challenges in getting close enough to the animal for accurate delivery of the biobullet via compressed air-powered rifle (< 30 meters), and (2) the likelihood that bison groups will not tolerate persistent remote delivery to every individual in the group during one encounter period.
4. The monitoring program will include the marking (e.g., ear tag placement, passive integrated transponders) of bison handled in capture facilities and during remote capture operations using chemical immobilization drugs.
5. The Stephens Creek bison capture facility will be used as a monitoring tool to handle bison regardless of whether seropositive bison will be consigned to slaughter.

F.2 Cost Estimate for Additional Studies Needed to Resolve Uncertainties of Delivery

$200,000	Captive study to determine the strength and duration of the immune response in bison following remote delivery vaccination for brucellosis via biobullet.
$15,000	Shelf-life study to estimate the length of time the encapsulated vaccine will survive prior to field delivery. This study will determine whether the encapsulation process needs to be done frequently or, potentially, as infrequently as once per year.
$15,000	Encapsulation study to develop a biomarker capable of being imbedded in the remote delivery projectile casing so that making estimates of long-term vaccine immune response can be estimated and monitored)
$230,000	*Research Subtotal*

F.3 Cost Estimate for Necessary Equipment (One-time Purchase)

$4,000	Chemistry equipment to do encapsulation work
$5,000	Remote delivery rifles
$30,000	Passive integrated transponder readers, software and training
$3,000	Compressed air-powered paint ball pistols/rifles
$5,000	Optical equipment such as scopes, binoculars, and rangefinders
$47,000	*Equipment Subtotal*

F.4 Cost Estimate for Field Delivery Program

$6,000	Aerial survey to direct ground crews
$108,000	Staff to conduct vaccination program (i.e., four 2-person crews for nine pay periods)
$5,600	Vehicles (gas and rental for the autumn season)
$3,000	Vehicles (gas and rental for the spring season)
$10,000	Operating expenses for supplies and equipment (e.g., mace, safety supplies, batteries, optics, ski gear)
$13,700	Vaccine procurement (1,000 doses of vaccine ($1,200); contract to train staff, develop protocol for first year, and produce the first year's batch of encapsulated projectiles ($10,000); empty projectiles to load with vaccine ($500); and disposable supplies ($2,000))
$146,300	*Annual Field Delivery Subtotal*

F.5 Funding Sources and Cost Estimate for Monitoring Program

Potential funding sources for surveillance activities to assess the effects and effectiveness of the IBMP, including in-park vaccination are indicated in Table F1.

F.5.1 Stephens Creek

The current vaccination program has been connected with the brucellosis risk management program at the Stephens Creek capture facility where bison are captured, sometimes tested and held, and at other times shipped to slaughter without testing. Delivery of vaccine through syringe injection during this process requires insignificant additional cost and work load as the vaccine costs about $1 per dose and bison are vaccinated during the risk management handling procedures.

$70,000	Staff to run a 10-week brucellosis testing program at the Stephens Creek capture facility, including the monitoring of brucellosis infection rates
$17,000	Disposable supplies (e.g., test kits, syringes, glassware, gloves, ear tags, passive integrated transponders)
$15,000	Laboratory analyses of feces, tissues, and blood
$102,000	*Annual Stephens Creek Monitoring Sub-Total*

F.5.2 Field Monitoring of Chemically Immobilized Bison

A field monitoring program to (1) sample individual bison following parturition, and (2) collect parturition tissues will be conducted to supplement the pen studies and capture pen monitoring work done at Stephens Creek facility.

$32,000	Field immobilization to collect samples of blood, swabs and nutritional indices ($800 per bison capture)
$10,000	Laboratory work to have samples diagnosed
$42,000	*Annual Field Monitoring Sub-total*

F.6 Projected Cost per Proposed Alternative

F.6.1 Alternative A

Vaccination delivery and monitoring is limited to work at the boundary capture pens ($102,000)

F.6.2 Alternative B

Vaccination delivery includes work at the boundary capture pens and remote delivery of encapsulated vaccine to calves and yearling females.

Research studies	$230,000
One-time equipment purchase	$ 47,000
	$277,000
Annual vaccine delivery costs	$146,300
Annual monitoring costs	$144,000
	$290,300

F.6.3 Alternative C

Vaccination delivery includes work at the boundary capture pens and remote delivery of encapsulated vaccine to calves and all females older than one year of age. The cost to implement this alternative is the same as the cost to implement Alternative B. The difference would be the number of individual bison that receive vaccine projectiles. All monitoring costs and efforts would be exactly the same for Alternatives B and C.

Research studies	$230,000
One-time equipment purchase	$ 47,000
	$277,000
Annual vaccine delivery costs	$146,300
Annual monitoring costs	$144,000
	$290,300

Table F1. Funding sources for surveillance activities to assess the effects and effectiveness of the Interagency Bison Management Plan, including in-park vaccination

Surveillance Activity	National Park Service	Other IBMP Partners	Yellowstone Park Foundation	Additional Funding Needed
1. Estimate abundance, demography, and limiting factors for bison.	X	–	–	–
2. Describe migratory and nomadic movements by bison.	X	–	–	–
3. Estimate heterozygosity, allelic diversity, and probabilities of genetic conservation	X	–	–	–
4. Estimate brucellosis transmission risk within and between species and areas.	X	X	X	–
5. Estimate age-specific serostatus and culture status rates for brucellosis in bison.	X	X	–	–
6. Determine rates of recrudescence (i.e., latent carriers of *Brucella*.	X	–	–	–
7. Determine factors influencing brucellosis infection and transmission.	X	X	X	–
8. Estimate the timing and proportion of bison removals each year.	X	X	–	–
9. Document bison use of risk management zones and commingling with livestock.	X	X	–	–
10. Estimate the effects of hazing or temporarily holding bison in capture pens.	X	–	–	–
11. Determine the strength and duration of the immune response in bison following syringe delivery vaccination for brucellosis.	–	X	X	X
12. Determine the strength and duration of the immune response in bison following remote delivery vaccination for brucellosis.	–	–	–	X
13. Document long-term trends in the prevalence of brucellosis and shedding in bison, and the underpinning effects of in-park vaccination.	–	–	–	X

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Appendix G: 106 Consultation Concurrence Letter

20061213051

United States Department of the Interior

NATIONAL PARK SERVICE
PO Box 168
Yellowstone National Park
Wyoming 82190

IN REPLY REFER TO:

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DEC 18 2006
SUPERINTENDENT'S OFFICE

H3015(YELL)
xN1427

DEC 11 2006

CONCUR
MONTANA SHPO
DATE 12/15/06 SIGNED

Stan NPS-Yellowstone free-ranging Yellowstone bison vaccination

Dr. Mark Baumler
Montana State Historic Preservation Officer
Montana Historical Society
P.O. Box 201202
Helena, Montana 59620-1202

Subject: Proposed Vaccination of Free-ranging Yellowstone Bison

Dear Dr. Baumler:

Yellowstone National Park (YNP) is conducting an Environmental Impact Study (EIS) to assess the feasibility of implementing a remote delivery brucellosis vaccination program for bison as directed in the 2000 Record of Decision for the Bison Management Plan for the State of Montana and Yellowstone National Park. Cultural consultation on the vaccination program was initiated in June 2005 as part of the early planning effort to assess the impact of the proposed undertaking. The EIS will be available for full review and comment in the near future. At this time, YNP would like to work toward final consultation under Section 106 of the National Historic Preservation Act, as amended, on the effect of the proposed bison free range vaccination undertaking on YNP's known cultural resources.

The preferred alternative proposed in YNP's current undertaking would use pneumatic rifles to deliver a bio-absorbable projectile (bio-bullet) to individual animals in Yellowstone. Vaccine delivery in the park will occur throughout the yearlong range of bison generally wherever bison groups are encountered. Field operations would avoid high density human use areas (like residential, visitor center and hotel locations). The bulk of the vaccination operation will take place between late fall and early spring when the ground is frozen. Typically, delivery will occur in open valleys (grass and sagebrush habitats), but may also occur in forested areas (lodgepole pine) where bison travel between ranges.

The proposed vaccination delivery program is not anticipated to involve surface or sub-surface ground disturbance. The bison distribution identified in Figure 1 (enclosed) includes areas known to contain surface and subsurface archeological and cultural resources. A large scale map of archeological site distribution throughout YNP is included in the enclosed information. Due to the large area in which bison range across

YNP and the lack of advance knowledge of the locations where the vaccination procedures will be conducted, it is not possible to conduct archeological surveys prior to the undertaking. Yellowstone's bison program staff has worked closely with YNP archeologists and ethnography program staff in the past and will continue to do so to insure that surface manifestations of archeological sites are recognized so that any new impact to the cultural resources can be avoided. Any surface disturbance created by the undertaking would be similar to the natural movements of humans and animals across the landscape. Yellowstone has archeological inadvertent discovery procedures in place to address field discovery situations to aid in avoiding impact to cultural sites. Yellowstone National Park considers bison as a component of the ethnographic resources important to associated tribes. Tribal consultation concerning the vaccination program indicates mixed opinions about support for the project as it relates to the ethnographically significant bison population.

Therefore, YNP has determined that the preferred alternative for vaccination of free ranging bison may have an impact on historic properties, but no historic properties will be adversely affected by the undertaking. We request your concurrence with this determination, concluding the NHPA Section 106 consultation of affect for this undertaking. If you have questions, please contact Rick Wallen, Wildlife Biologist, Team Leader, Bison Ecology and Management Program, at (307) 344-2207.

Sincerely,

Suzanne Lewis
Superintendent

Enclosures

cc:
Rick Wallen w/ enclosure
Elaine Hale
Roger Anderson
Ann Johnson
Rosemary Sucec

ARTS. PARKS. HISTORY.
Wyoming State Parks & Cultural Resources

State Historic Preservation Office
Barrett Building, 3rd Floor
2301 Central Avenue
Cheyenne, WY 82002
Phone: (307) 777-7697
Fax: (307) 777-6421
http://wyoshpo.state.wy.us

RECEIVED
DEC 18 2006
SUPERINTENDENT'S OFFICE

Dec 14, 2006

Suzanne Lewis
Superintendent
Yellowstone National Park
P.O. Box 168
Yellowstone NP, WY 82190

Re: Vaccination of free-ranging Yellowstone Bison (SHPO File # 1206JRD011)

Dear Ms. Lewis:

Thank you for consulting with the Wyoming State Historic Preservation Office (SHPO) regarding the above referenced project. We have reviewed the project report and find the documentation meets the Secretary of the Interior's Standards for Archaeology and Historic Preservation (48 FR 44716-42). We concur with your finding that no historic properties, as defined in 36 CFR § 800.16(l)(1), will be affected by the project as planned.

We recommend Yellowstone National Park allow the project to proceed in accordance with state and federal laws subject to the following stipulation:

> If any cultural materials are discovered during construction, work in the area shall halt immediately, the federal agency must be contacted, and the materials evaluated by an archaeologist or historian meeting the Secretary of the Interior's Professional Qualification Standards (48 FR 22716, Sept. 1983).

This letter should be retained in your files as documentation of a SHPO concurrence on your finding of no historic properties affected. Please refer to SHPO project # on any future correspondence regarding this project. If you have any questions, please contact 1206JRD011 at 307-777-8793.

Sincerely,

Joseph Daniele
State Historic Preservation Office

Dave Freudenthal, Governor
Milward Simpson, Director

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Appendix H: Surveillance Plan

P.J. White, John Treanor, and Rick Wallen
National Park Service, Yellowstone National Park, Wyoming

Executive Summary

The successful conservation of bison in Yellowstone National Park from 44 animals in 1902 to a high of 5,015 by 2005 has led to an enduring series of disagreements among various publics and management entities regarding bison abundance and distribution, and the potential transmission of the *Brucella* pathogen to domestic cattle. For the purposes of this surveillance plan, Yellowstone bison are the resource that historically occupied an area of approximately 20,000 km^2 in the headwaters of the Yellowstone and Madison rivers, in what is now referred to as the northern GYE. Since the Record of Decision was signed for the IBMP by the State of Montana and the NPS in 2000, progress has been slow at completing the plan's successive adaptive management steps, and the Government Accountability Office has recommended that the IBMP agencies develop specific management objectives, conduct surveillance to evaluate the effects and effectiveness of management actions, and methods for adjusting the IBMP based on these assessments (U.S. Government Accountability Office 2008). Also, under provisions of the IBMP, the NPS is considering implementation of a long-term, remote delivery, vaccination program for brucellosis in free-ranging bison inside Yellowstone National Park. Thus, commensurate with the IBMP, there is a demonstrated need to estimate key parameters of bison and brucellosis dynamics and evaluate the likely effects and effectiveness of a variety of management activities. The purpose of this surveillance plan is to identify a comprehensive suite of long-term monitoring and research activities for Yellowstone bison that meet the mission of the NPS and inform IBMP adaptive management.

Surveillance activities described herein are collated according to three primary themes of conservation management for bison at Yellowstone National Park.

<u>Conservation (Preserve a Functional, Free-Ranging Bison Population)</u>

1. Estimate the abundance, demographic rates, and limiting factors for the overall bison population and two primary subpopulations.
2. Describe migratory and nomadic movements by bison at a variety of temporal and spatial scales in and outside the park.
3. Estimate the existing heterozygosity, allelic diversity, and long-term probabilities of genetic conservation for the overall bison population and identified subpopulations.

<u>Risk Management (Prevent Brucellosis Transmission from Bison to Livestock)</u>

4. Estimate the probabilities (i.e., risks) of brucellosis transmission within and between species (i.e., bison, cattle, elk) and areas (e.g., elk feed grounds in Wyoming and the northern GYE).
5. Estimate age-specific rates of bison testing seropositive and seronegative for brucellosis that are also culture positive and the proportion of seropositive bison that react positively on serologic tests due to exposure to cross-reactive agents other than *B. abortus* (e.g., Yersinia).
6. Determine rates of recrudescence (i.e., latent carriers of *Brucella* that relapse to an infectious state) in bison.

7. Determine how the interactive effects of pregnancy, stress, and nutritional condition influence the vulnerability of bison to brucellosis infection and transmission.
8. Estimate the timing and proportion of removals from each of the two primary subpopulations each winter, including the proportion of removals from each age and sex class.
9. Document bison use of risk management zones outside the northern and western boundaries of Yellowstone National Park and commingling with livestock during the likely brucellosis-induced abortion period for bison each spring.
10. Estimate the effects of hazing or temporarily holding bison in capture pens at the boundary of Yellowstone National Park (for spring release back into the park) on subsequent bison movements or possible habituation to feeding.

Brucellosis Suppression (Reduce Disease Prevalence)

11. Determine the strength and duration of the immune response in bison following syringe delivery vaccination for brucellosis.
12. Determine the strength and duration of immune response in bison following remote delivery (e.g. biobullet) vaccination for brucellosis.
13. Document long-term trends in the prevalence of brucellosis in bison, and the underpinning effects of remote and/or hand vaccination, other risk management actions (e.g., harvest, culling), and prevailing ecological conditions (e.g., winter-kill, predation) on these trends.

To accomplish this suite of surveillance activities, NPS staff will work with the IBMP partners (Animal and Plant Health Inspection Service, Forest Service, Montana Department of Livestock, Montana Fish, Wildlife, and Parks), the Yellowstone Wildlife Health Program, and other scientists and stakeholders to implement field, controlled, and laboratory studies to collect empirical data for evaluating progress. The data will be used to develop and parameterize models that will serve as analytical tools for evaluating how bison and brucellosis may respond to management actions within specified confidence bounds.

This surveillance program will provide timely and useful information to help develop adaptive management adjustments needed to conserve Yellowstone bison, reduce the risk of brucellosis transmission from bison to cattle, and reduce the prevalence of brucellosis in the bison population. Through regularly scheduled IBMP meetings, NPS staff will solicit review, comment, and discussion from agency partners and key stakeholders in the refinement of objectives, design of monitoring and research, and assessment of findings to build support for the legitimate process and provide a foundation for learning-based resource management.

The complete document of the surveillance plan is available at <http://www.greateryellowstonescience.org/topics/biological/mammals/bison/projects/vaccination/reports> or from Rick Wallen, Yellowstone Center for Resources, P.O. Box 168, Yellowstone National Park, Mammoth, Wyoming 82190.

Appendix I: Surveillance for Brucellosis in Yellowstone Bison: The Power of Various Strategies to Detect Vaccination Efforts

Technical Report for the National Park Service, August 2008
Michael R. Ebinger[1]
Paul C. Cross[2,3]
[1] Big Sky Institute, Montana State University, Bozeman, MT 59717
[2] Ecology Department, Montana State University, Bozeman, MT 59717
[3] Northern Rocky Mountain Science Center, U.S. Geological Survey, Bozeman, MT 59717

Executive Summary

Monitoring of brucellosis seroprevalence in bison requires the collection of blood samples that are gathered when (1) bison migrate out of the park during winter (boundary captures), and (2) bison are captured for research purposes (research captures). Boundary captures are highly variable from year to year but occasionally yield large samples, while research captures are likely to be small (i.e., <100), but less variable. A simulation approach was developed to estimate how many years it takes to detect a change in seroprevalence, which was modeled phenomenologically as a linear or logistic decrease over time. Three analytical approaches were compared: single year estimate; 3-year running average; and regression using all years to date.

Sample size had a larger influence on the year of first detection for the linear decrease scenarios. Estimates of the year of first detection were less variable for logistic decreases because the "steepness" of the logistic curve concentrates the span of years where large decreases occur. As end prevalence increased (range = 0.0-0.30), the year of first detection also increased for both decrease scenarios under all levels of research samples. The rate of the seroprevalence decrease appeared to have its strongest influence on the year of first detection for the single year and moving average methods under the linear decrease scenario.

Attempting to detect a change in seroprevalence from annual data involves multiple statistical tests over time and the probability of a type I error (detecting a difference that does not exist) increases with the number of statistical tests. This presents a challenge of satisfying two conflicting requirements: reduce the risk of reporting false positives (i.e., Type I errors), but maintain the likelihood an effect will be detected if it exists. Simulation of Type I error rates shows that the single-year and 3-year moving average are more conservative and less prone to Type I errors than the cumulative years regression approach.

The single-year estimate and 3-year moving window average estimate produced similar results in terms of the median year of first detection. However, the variation around this median estimate differed between the two approaches. The single-year estimate approach consistently showed more variation surrounding the median. On average, the regression model tended to be a more powerful approach, though differences were typically in the 1-2 year range. However, the regression approach also showed more variation around this estimate for the gentler decreases in prevalence. The change in research captures had surprisingly little effect on the year of first detection. The major contribution of increased research captures was in reducing the variation associated with the year of first detection. More research captures buffer against

the possibility of going through several mild winters when very few boundary captures may occur. If research captures can take place after late winter, then information about over-winter boundary samples would be able to direct managers to how many additional samples are needed to achieve a minimum sample size. For the scenarios explored, analyses suggest that sampling during the initial years of a vaccination program is unlikely to detect any significant change in prevalence.

The complete document of these power analyses (Ebinger and Cross 2008) is available at http://www.greateryellowstonescience.org/topics/biological/mammals/bison/projects/vaccination/reports or from Rick Wallen, Yellowstone Center for Resources, P.O. Box 168, Yellowstone National Park, Mammoth, Wyoming 82190.

Appendix J: Vaccination Strategies for Managing Brucellosis in Yellowstone Bison

John Treanor[1,2], Joseph Johnson [3], Rick Wallen[1], Sara Cilles[2], Phil Crowley[2], and Dave Maehr[3]

[1] National Park Service, Yellowstone National Park, Wyoming
[2] Department of Biology, University of Kentucky, Lexington, Kentucky
[3] Department of Forestry, University of Kentucky, Lexington, Kentucky

Final Report, Yellowstone Center for Resources, October 2007

Executive Summary

Models are useful decision-making tools for evaluating management strategies when it is necessary to proceed despite uncertainty. Concerns over bison in Yellowstone National Park transmitting brucellosis to cattle herds adjacent to the park led to the development of an interagency management plan that identified vaccination as a potential method for reducing the risk of transmission. An individual-based model was developed to estimate how brucellosis infection might respond under alternate vaccination methods over a 30-year period, including (1) vaccination of female calves and yearlings captured at the park boundary when bison move outside the primary conservation area, (2) combining boundary vaccination with the remote delivery of vaccine to female calves and yearlings distributed throughout the park using bio-absorbable projectiles (biobullets), and (3) vaccinating all female bison (including adults) during boundary capture and remote delivery operations. Simulations suggest the goal of reducing brucellosis transmission risk to livestock outside the park can be best achieved by combining boundary capture and remote delivery vaccination of all female bison. Simulations of this alternative estimated seroprevalence could decrease by 66% from 0.47 to 0.16 over the 30-year simulation period, with 29% of the population vaccinated. Boundary removals resulting from migrations out of the park were stochastic, but fewer seropositive bison were removed at the boundary as the number of vaccinated bison that received protection from the vaccine increased in the population. Also, this alternative allows bison to receive multiple vaccinations that extend the duration of vaccine protection and defend against recurring infection in latently infected animals. Initially, the decrease in population seroprevalence will likely be slow because of high initial seroprevalence (40-60%), long-lived antibodies, and the likely culling of some vaccinated bison that are subsequently exposed to field strain *Brucella* and react positively on serologic tests. Though vaccination is unlikely to eradicate *B. abortus* from Yellowstone bison, it can be an effective tool for reducing the level of infection and, in turn, allow for incorporating advances in the fields of diagnostics, vaccine development, and delivery into adaptive management programs.

The complete document of the modeling report (Treanor et al. 2007b) is available at http://www.greateryellowstonescience.org/topics/biological/mammals/bison/projects/vaccination/reports or from Rick Wallen, Yellowstone Center for Resources, P.O. Box 168, Yellowstone National Park, Mammoth, Wyoming 82190.

Summary of Methods Used to Develop the Analysis Model

NPS staff and collaborators at the University of Kentucky created a stochastic, individual-based model to simulate the epidemiology of the disease under different vaccination scenarios and to evaluate differences in management alternatives aimed at reducing brucellosis seroprevalence in Yellowstone bison. Accurately quantifying infectious events and the proportion of the population with an acquired immunity from vaccination is difficult to impossible because of the large landscape bison occupy and the insensitive tests available to estimate these parameters. However, random samples taken from individual bison can be used to estimate population seroprevalence, and the number of seropositive bison removed from the population during boundary risk management operations can be monitored over time to evaluate the predictive capability of this model.

The individual-based model was developed using MATLAB 7 software to carry out simulations of system functions (Figure J1). The model tracked information (i.e., age, sex, disease status, pregnancy status, vaccination status, management removal) on each female bison born into the population. Though male bison were monitored for population growth and seroprevalence, they were assumed to have no role in brucellosis transmission and were not a focal component of the model. The model grouped bison into four specific disease classes (i.e., susceptible, infected, latent, and vaccinated) based on exposure, the course of infection, and vaccination status. Individuals changed their disease class based on events (e.g., exposure to *B. abortus* and vaccination) and rules associated with their current state (e.g., disease class, pregnancy status, vaccination status).

The model used both yearly and daily time steps. Events occurring in the yearly time step were bison mating, natural mortality, and management operations (e.g., removal of seropositive bison and vaccination). The daily time step detailed the processes that led to shedding and transmission of *B. abortus* among Yellowstone bison. The model was initialized with each individual being assigned demographic information (i.e., sex and age) and disease status (i.e., susceptible, infected, or latent). Age was assigned based on actual classification data of Yellowstone bison and sex was assigned assuming an equal sex ratio. Bison were assigned their disease status based on estimates from Yellowstone bison seroprevalence data. Yearly outputs were stored and projected after the model was run for 30 annual cycles.

Model parameters (Table J1) were estimated from published literature and the best available information. Bison in the model were assumed to have a lifespan of 15 years (Pac and Frey 1991) unless they died earlier at specified mortality rates. The calving period was modeled for 61 days (Berger and Cain 1999) during which female bison reproduced based on estimates of Yellowstone bison pregnancy and calving rates. Based on Roffe et al. (1999), 46% of seropositive bison were assumed to be culture positive and classified as infected for initializing the model. Infected individuals were those harboring live *B. abortus* and expected to abort their first pregnancy following infection with high probability (96%). The remaining 54% of seropositive bison were assigned to the latent class. Adult, latent, pregnant bison recrudesced (i.e., relapsed) and shed *B. abortus* during live infectious births at a specified probability (0.05). Abortions and infectious live births were treated equally with regard to disease transmission. A proportion of calves born during these infectious live births also became infected through vertical transmission at a specified probability (0.66). For the purpose of diagnosing bison during management operations, the standard field serology tests were assumed to identify all actively infected and 95% of latently infected bison. The model also assumed no additional abortions or mortalities resulted from vaccination.

Management removals simulated brucellosis risk management operations for bison movements to winter range areas outside the park. The proportion of the bison population captured in a given year was estimated from bison capture histories over the past 20 years. Based on this information, intervals (0-10, 10-20, and 20-30%) were established to simulate the percentage of bison tested at the boundary management areas. Bison determined to be positive reactors to serological tests were removed and nonreactors were vaccinated and remained a part of the population. Based on studies by Nielsen and Gaul (2001), all bison in the infected class and 94% of the latent class were identified as reactors (sero-positive for brucellosis). During each annual cycle, bison were added to the vaccinated class of individuals depending on their probability of being encountered at the capture facility or remotely in the park depending on the alternative. Vaccine efficacy was modeled as the probability that a vaccinated bison would enter the vaccine protected class. Bison in this class were protected from *B. abortus* shed via infectious abortions or live births. Model simulations for remote vaccination alternatives included randomly selecting 50% of the target group (i.e., calves and yearlings for Alternative B; calves, yearlings, and adult females for Alternative C) each year as vaccinates. Using an intermediate level of vaccine efficacy (50%), approximately 25% of the target group received protection from the vaccine under this alternative—meaning bison in the protected category would not subsequently become infectious and shed bacteria if exposed to an infectious event.

Brucellosis research demonstrates that bison responses to the disease and vaccination are variable. The individual-based modeling approach addressed this variability by modeling each individual within the population. Rules and probabilities were assigned based on the disease state of each individual to make simulations more realistic. The yearly outputs were used to understand disease dynamics under each of the proposed alternatives. Multiple simulations were compared for identifying the variation in model runs. Each run provided a trajectory of the disease state in the population over the period modeled. The average trajectory of multiple runs was used to project the outcome for each alternative.

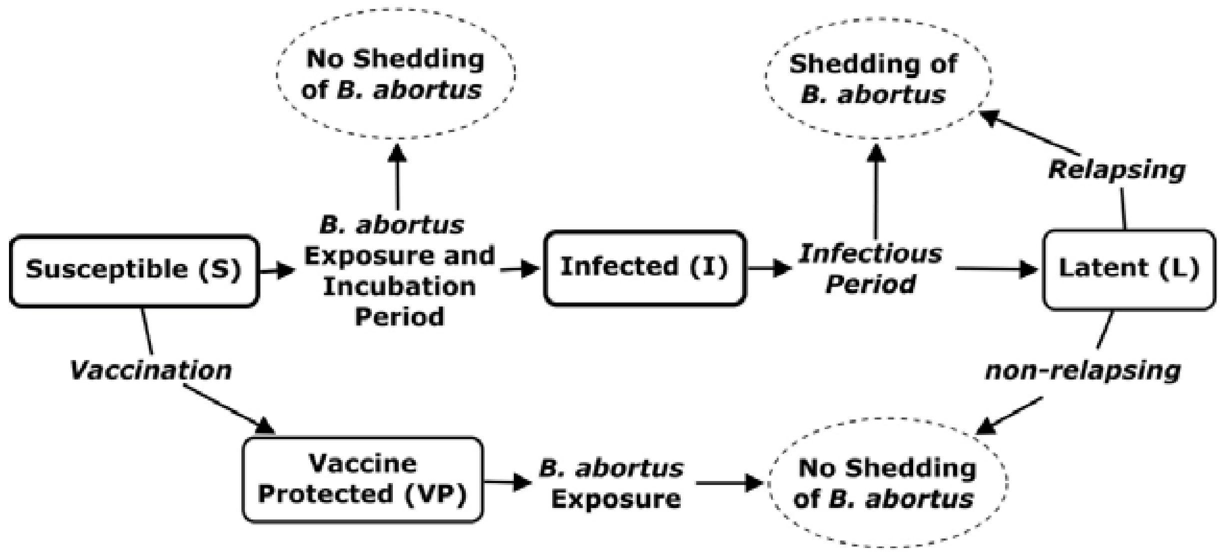

Figure J1. Description of model processes: Susceptible female bison (i.e. never exposed to *B. abortus*) become infected following exposure (i.e. ingesting *B. abortus*) and an incubation period (i.e., period of *B. abortus* growth within bison). Most of these infected bison will shed *B. abortus* when pregnant via a *B. abortus* induced abortion. Following this infectious period, bison enter a latent phase where most will not shed *B. abortus* during future pregnancies. A small percentage of latent bison will relapse during pregnancy and shed *B. abortus* via birth tissues and fluids. A high percentage of calves born to relapsing bison cows will be infected. Vaccination was modeled to prevent *B. abortus* transmission (i.e., shedding during pregnancy) based on the efficacy of the vaccine (i.e., vaccination did not protect all bison receiving the vaccine). Bison that were protected through vaccination did not shed *B. abortus* if they became exposed following vaccination.

Table J1. Default parameters for the analysis model used to evaluate impacts to the bison population

Parameter/Variable	Value	Source
Pregnancy rate (Pr)		Yellowstone National Park
• calves and yearlings 0-1	0	
• 2-year-olds	0.71	
• 3-year-olds	0.79	
• 4-year-olds	0.76	
• Adults (≥5 years)	0.89	
Calving rate (Cr)	0.71	Yellowstone National Park
Birth period (Bdays)	61 days	Berger and Cain (1999)
Abortion period (Adays) (prior to parturition date)	90 days	National Research Council (1998)
Death rate (Dr)		Dobson and Meagher (1996)
• 0-2 years	0.2	(Modified for age classes)
• 3-13 years	0.1	
• 14 years	0.2	
• 15 years	1.0	
• Virulence (brucellosis addition to death rate)	0.005	
Group size (parturition/abortion period)		Yellowstone National Park
Minimum	24	
Maximum	48	
Disease State		Yellowstone National Park and Montana
• Susceptible (S)	0.53	Department of Livestock;
• Infected (I)	0.22	Calculated using Roffe et al. (1999)
• Adult Latent (L) (infected but not infectious)	0.25	
Rate of recrudescence	0.05	Fitted value (analyzing sensitivity)
Exposures per infectious event (MUs)	1	Fitted value (analyzing sensitivity)
Vertical transmission (vxm)	0.66	Gross et al. (1998)
Minimum incubation	35 days	Gross et al. (1998)
Beta (β) (social transmission factor)	1.5	Fitted parameter
Bison Captures (at park boundary in any given year)		Yellowstone National Park (past 20 yrs)
• 0-10% of population captured	0.84	
• 10-20% of population captured	0.11	
• 20-40% of population captured	0.05	
Bison Removals at Capture Facility		
• Removal of infected class	1.0	
• Removal of latent class	0.94	
Vaccination (injection and biobullet)		Olsen (2004) Draft Summary
• Vaccine duration (VE)		modeled over a range of values
• Vaccine protection (VR)		modeled over a range of values

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Appendix K: Section 7 Consultation Concurrence Letter

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Ecological Services
5353 Yellowstone Road, Suite 308A
Cheyenne, Wyoming 82009

RECEIVED
JAN 16 2007
SUPERINTENDENT'S OFFICE

In Reply Refer To:
ES-61411/W.25/WY07I0072

JAN 12 2007

Memorandum

To: Suzanne Lewis, Superintendent, National Park Service, Yellowstone National Park, Wyoming

From: Brian T. Kelly, Field Supervisor, Wyoming Field Office, U.S. Fish and Wildlife Service, Cheyenne, Wyoming

Subject: National Park Service's proposed brucellosis vaccination program for bison in Yellowstone National Park

Thank you for your letter, dated December 5, 2006, and enclosed biological assessment, received by our office on December 7, 2006, initiating informal consultation under section 7 of the Endangered Species Act of 1973, as amended (Act; 50 CFR § 402.13) for the effects of brucellosis vaccination for bison (*Bison bison*) in Yellowstone National Park. The National Park Service (NPS) proposes to implement remote delivery of brucellosis vaccine (*Brucella abortus* RB51 strain) to free-ranging bison throughout Yellowstone National Park. The preferred alternative for vaccination is the use of a pneumatic rifle to deliver a bio-absorbable projectile carrying a vaccine payload; however the delivery method used may be modified during the implementation period of the proposed action. Multiple field teams will coordinate vaccination activities and will adapt their particular approach based upon landscape characteristics and behavioral response of bison. While exact delivery time is uncertain, the proposed vaccination activities may occur from about mid-September though the month of June, focusing on adults in the fall and early winter, and on calves, yearlings and two-year old bison in late winter and spring.

Threatened and Endangered Species

The Federally listed species addressed in the NPS biological assessment include: Canada lynx (*Lynx canadensis*), grizzly bear (*Ursus arctos horriblis*), gray wolf (*Canis lupus*), and bald eagle (*Haliaeetus leucocephalus*).

Canada Lynx: The NPS biological assessment concluded that the proposed bison vaccination plan may affect, but is not likely to adversely affect Canada lynx due to the typically different habitat requirements of bison and lynx within the park. The lack of habitat overlap makes it unlikely that individual lynx will scavenge carcasses of newly vaccinated bison. Furthermore, according to the information in the assessment, lynx are unlikely to be displaced more than a short distance by human activity during vaccination periods. While research on other carnivores suggests that consumption of *B. abortus* strain RB51 (SRB51) has no significant effects, there are limited data available for felids.

Grizzly Bear: The biological assessment states that vaccination activities will coincide with fall denning periods and spring emergence of grizzly bears, that vaccination activities will not occur in areas where grizzly bears are observed, and that bears will be avoided and given a large amount of space when possible. Vaccination of bison will also not occur in important bear foraging areas such as moth sites, whitebark pine stands, or near cutthroat trout spawning streams. Grizzly bears orally exposed to SRB51 show no adverse clinical, histological or reproductive effects.

Gray Wolf: While wolf packs occur throughout Yellowstone National Park in areas used by bison, vaccination activities would likely result only in localized displacement of individual wolves. During the denning season, vaccination activities will not be carried out within one mile of known wolf dens, and carrion used by wolves will be avoided. Research on possible negative effects of canid exposure to SRB51 indicates that there will be no associated morbidity or mortality in wolves that may consume carrion from bison vaccinated with SRB51.

Bald Eagle: Vaccination activities will take place during the bald eagle nesting season (February – June), however, a distance of one-quarter mile will be maintained from individual nests. Due to the short duration, light intensity and low frequency of the proposed vaccination activities, it is unlikely that there will be any substantive disturbance of nesting eagles. No research has been conducted on the effects of SRB51 exposure in bald eagles. Limited data are available on the potential negative effects of direct exposure to avian species, although exposure studies conducted on ravens showed no morbidity of mortality effects of oral exposure.

Based on the information provided in the NPS biological assessment and listed above, the U.S. Fish and Wildlife Service (Service) concurs with your determination that the proposed action may affect, but is not likely to adversely affect Canada lynx, grizzly bear, gray wolf and bald eagle.

Additional Recommendations

While some research has shown vaccination of pregnant bison with SRB51 is safe and free of significant adverse effects (Elzer et al., 1998), other research has indicated that SRB51 exhibits tropism for the bison placenta and can cause placentitis which may induce abortion (Palmer et al., 1996). Vaccination activities as described in the NPS biological assessment propose targeting adult bison in the fall and early winter. Although this timing means that many pregnant females would be vaccinated relatively early during pregnancy, those vaccinated towards the end of this period, and closer to mid-gestation, may face a higher risk of aborting. An increase in abortions and presence of fetal tissue in the environment may act as an attractant to raptors and migratory birds, as well as other wildlife. This may have the unforeseen effect of causing wildlife to congregate in the vicinity of where vaccination activities are occurring. Considering the disparity of results on the safety of SRB51 vaccine in pregnant bison, and fact that large-scale vaccination of free-ranging bison without capture has not been attempted before, the Fish and Wildlife Service believes that a need for monitoring of the proposed action exists.

It is generally accepted that additional data on the safety and efficacy of the SRB51 vaccine in bison is needed, and this proposed action represents a superb opportunity to acquire such information. The relative benefits of monitoring progress and efficacy of the proposed action would far outweigh the associated costs. Furthermore, the ability of the NPS to actively adapt implementation of the proposed action in order to respond to environmental and technological changes will be enhanced by an effective monitoring strategy.

Elements of such a strategy would ideally include monitoring:

- whether abortions are occurring and, if so, whether this results in attraction or congregation of migratory birds or other wildlife
- the rate of abortion in vaccinated females, with particular attention to animals vaccinated after 100 days gestation
- whether shedding of the vaccine is occurring
- the duration of immunity

This concludes informal consultation pursuant to the regulations implementing the Act. However, for tracking purposes we ask that you notify us when a decision has been made and the proposed action is to begin.

This project should be re-analyzed if new information reveals effects of the action that may affect listed or proposed species or designated or proposed critical habitat in a manner or to an extent not considered in this consultation; if the action is subsequently modified in a manner that may affect a listed or proposed species or designated or proposed critical habitat that was not considered in this consultation; and/or, if a new species is listed or critical habitat is designated that may be affected by this project.

Thank you for your efforts to ensure the conservation of threatened and endangered species in Wyoming. If you have any questions regarding this letter or your responsibilities under the Act, please contact Tyler Fox at the letterhead address or by calling (307) 772-2374, extension 237.

cc: WGFD, Statewide Habitat Protection Coordinator, Cheyenne, WY (V. Stelter)
WGFD, Non-Game Coordinator, Lander, WY (B. Oakleaf)

References

Elzer, P.H., M.D. Edmonds, S.D. Hagius, J.V. Walker, M.J. Gilsdorf, and D.S. Davis. 1998. Safety of *Brucella abortus* strain RB51 in Bison. *Journal of Wildlife Diseases*. 34(4): 825-829

Palmer, M.V., S.C. Olsen, M.J. Gilsdorf, L.M. Philo, P.R. Clarke, and N.F. Cheville. 1996. Abortion and placentitis in pregnant bison (*Bison bison*) induced by the vaccine candidate, *Brucella abortus* strain RB51. *American Journal of Veterinary Research*. 57(11): 1604-1607

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

March 2010

National Park Service
U.S. Department of the Interior

Yellowstone National Park
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