National Park Service
U.S. Department of the Interior

Yellowstone National Park
Idaho, Montana, Wyoming

Remote Vaccination Program to Reduce the Prevalence of Brucellosis in Yellowstone Bison

FINAL Environmental Impact Statement

January 15, 2014

ON THE COVER
Bison in Yellowstone National Park. Photo: National Park Service (NPS).

Remote Vaccination Program to Reduce the Prevalence of Brucellosis in Yellowstone Bison

Final Environmental Impact Statement

Abstract

The National Park Service has completed an environmental impact statement (EIS) to evaluate whether to implement a remote-delivery vaccination program to decrease the prevalence of brucellosis in Yellowstone bison, a disease caused by the non-native bacteria *Brucella abortus* that can induce abortions in bison, elk, and cattle. This evaluation was directed by the 2000 Record of Decision for the Interagency Bison Management Plan. The goal of a vaccination program would be to deliver a low risk, effective vaccine to calf and female bison inside Yellowstone National Park to (1) decrease the probability of individual bison shedding *Brucella abortus*, (2) lower the brucellosis infection rate of Yellowstone bison, and (3) reduce the risk of brucellosis transmission to cattle outside the park. The migration of bison across the park boundary onto essential winter ranges in Montana would be preserved to facilitate their long-term conservation.

This EIS considered three alternatives: Alternative A—No Action, Alternative B—Remote Delivery Vaccination for Young Bison Only, and Alternative C—Remote Delivery Vaccination for Young Bison and Adult Females.

Under Alternative A—No Action, a remote vaccination program would not be implemented and continuation of the current hand vaccination program at Stephens Creek capture facility would occur. This alternative also includes continuation of the existing adaptive management process to learn more about the disease brucellosis. This process seeks to answer uncertainties, as well as develop or improve suppression techniques that could be used to facilitate effective outcomes, minimize adverse impacts, and lower operational costs of efforts to reduce brucellosis prevalence in the future. The National Park Service has identified Alternative A—No Action as the preferred alternative in this Final Environmental Impact Statement.

Alternative B includes a combination of the existing hand vaccination program at Stephens Creek under Alternative A and a remote delivery strategy that would focus exclusively on young, non-pregnant bison (both sexes). This alternative also includes continuation of the existing adaptive management process described under Alternative A.

Alternative C is similar to Alternative B, but also includes the remote vaccination of adult females.

This environmental impact statement analyzed the impacts in detail from all three alternatives for their effects on Yellowstone bison, threatened and endangered species, other wildlife, ethnographic resources, human health and safety, visitor use and experience and park operations.

The Draft EIS was released for public comment on May 28, 2010 and comments were accepted for more than 120 days. A total of 9,410 comments were received from 1,644 correspondences and distilled down to 6,620 substantive comments that were divided into 26 concern statements. Responses to public and agency comments via concern statements are included in Appendix B of this document and, where needed, as text changes in this final EIS. The publication of the Environmental Protection Agency (EPA) notice of availability of this final EIS in the Federal Register will initiate a 30-day waiting period before the Regional Director of the Intermountain Region will sign the Record of Decision, documenting the selection of an alternative to be implemented. After the NPS publishes a notice in the Federal Register announcing the availability of the signed Record of Decision, implementation of the selected alternative can begin.

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Bison in heavy snow fall near Pebble Creek in the northern portion of Yellowstone National Park. Photo: NPS.

U.S. Department of the Interior
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Remote Vaccination Program to Reduce the Prevalence of Brucellosis in Yellowstone Bison

Final Environmental Impact Statement Executive Summary

Brucellosis is a contagious disease caused by the non-native bacteria *Brucella abortus* that may induce abortions or the birth of non-viable calves in livestock and wildlife. When livestock are infected, there is economic loss to producers from slaughtering infected animals, increased brucellosis testing requirements, and possibly, decreased marketability of their cattle. Brucellosis has been eradicated in cattle herds across most of the United States, with the exception of occasional outbreaks in the greater Yellowstone ecosystem where bison and elk persist as one of the last reservoirs of infection. Approximately 40–60% of Yellowstone bison have been exposed to *Brucella abortus*.

After intensively managing bison numbers for 60 years through husbandry and culling, Yellowstone National Park instituted a moratorium on removing ungulates (hoofed animals) 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 migrations 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 federal and state agencies, environmental groups, and livestock producers regarding issues of bison conservation and brucellosis containment. As a result, the federal government and State of Montana agreed to a court-mediated Interagency Bison Management Plan in 2000 that established guidelines for managing the risk of brucellosis transmission from bison to cattle by implementing hazing, testing for brucellosis exposure, shipments of bison to domestic slaughter facilities, hunting outside Yellowstone National Park, vaccination, and other actions near the park boundary.

Vaccination has been proposed as a method to reduce brucellosis in Yellowstone bison by diminishing the clinical effects (abortions and the birth of live animals with *Brucella*) that maintain the disease through transmission. The currently available vaccine for bison (Strain RB51) has substantially reduced further brucellosis transmission in experimentally infected bison, but is less effective at preventing infection and will not prevent vaccinated bison (or cattle) from reacting positively on blood tests if they are exposed to field strain *Brucella*. 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 at parturition. However, it is uncertain how this vaccine will perform under field conditions, and results will likely vary from the experimental trials. Regardless, Strain RB51 vaccine is currently the best vaccine available for bison and cattle. Other vaccines (e.g., Strain 82, DNA) are undergoing testing, but it will likely be more than a decade before these evaluations are completed and their use is possible on bison or cattle in the United States.

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. 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 most feasible strategy for remote delivery of vaccine at this time is using an air-powered rifle to deliver an absorbable bullet with a vaccine payload that is freeze dried or photo-polymerized. The goal of vaccination is to deliver a low risk, effective vaccine to calf and female 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) reduce the risk of brucellosis transmission to cattle outside the park.

The Record of Decision for the 2000 Interagency Bison Management Plan also indicated that any untested vaccination-eligible bison allowed in the West Yellowstone, Montana area outside of Yellowstone National Park would be remotely vaccinated when a safe and effective remote delivery mechanism was available. The release of untested bison outside Yellowstone National Park would begin with the initiation of a vaccination program of bison inside the park with an effective remote delivery system. However, it is highly uncertain that the ballistic delivery of vaccine to bison would be effective given the current state of vaccine encapsulation and remote delivery technology. Methods for encapsulating vaccines into bio-absorbable projectiles under quality controlled production and consistently delivering the necessary dose of vaccine to bison using ballistic delivery or other systems need to be improved. In addition, little information is available to assess potential unintended behavioral consequences to bison from repeated remote-delivery vaccination over time.

Draft Environmental Impact Statement

A Draft Environmental Impact Statement for the Remote Vaccination Program to Reduce the Prevalence of Brucellosis in Yellowstone Bison was released for public comment on May 28, 2010 and comments were accepted for more than 120 days. Alternative A described the current hand vaccination program that has been intermittently implemented at capture facilities near the park boundary. Alternative B described a combination of the hand vaccination program at capture facilities and a remote-delivery vaccination strategy that would focus exclusively on young, non-pregnant bison. Alternative C described a combination of the hand vaccination program at capture facilities and remote-delivery vaccination of young, non-pregnant bison and adult females within the park prior to mid-gestation. For each alternative, the National Park Service analyzed potential environmental impacts divided into the following categories: bison population; other wildlife; threatened, endangered and sensitive species; ethnographic resources; human health and safety; visitor use and experience; and park operations.

The National Park Service received a total of 1,644 correspondences via letters, electronic mail (email), faxes, comments from public meetings, park forms, web forms submitted via the National Park Service's Planning, Environment and Public Comment website (PEPC), and other sources. These correspondences were distilled into 9,410 individual comments. From this correspondence, the National Park Service identified 6,629 substantive comments, which were divided into 26 concern statements. Most respondents associated with conservation constituencies opposed the remote vaccination program and recommended vaccination of cattle rather than bison. Conversely, most respondents associated with livestock groups supported remote vaccination (Alternative C). Many respondents suggested that the projected cost of park-wide remote vaccination ($300,000 per year for at least 30 years) was too expensive to justify the benefits, especially given the substantial uncertainties associated with vaccine efficacy, delivery, duration of vaccine protection, diagnostics, and bison behavior.

In addition, a Citizens Working Group comprised of people from a diverse group of stakeholders (including environmental groups and livestock producers), which was organized to seek responsible management solutions for Yellowstone bison, made a consensus recommendation after nearly a year of discussions that vaccination of wild bison using the current vaccine and remote delivery method should not be a priority at this time and that vaccination is unlikely to be effective at substantially reducing brucellosis prevalence in Yellowstone bison without the removal of infectious animals (both bison and elk) which serve as the primary transmission source.

In February 2013, the National Park Service and Montana Fish, Wildlife & Parks invited scientists from federal, state, academic, and non-governmental entities to (1) review what is known about the vaccine-induced immune responses of bison and elk, (2) review the benefits and limitations of existing tools and emerging technologies for suppressing brucellosis prevalence in Yellowstone bison and elk, (3) evaluate whether substantial brucellosis suppression is feasible and sustainable without significantly affecting bison behavior or visitor experience, and (4) provide guidance for the future direction of brucellosis suppression activities (including suitable tools, research, and surveillance), considering that the primary mission of the park is to preserve its natural and cultural resources for the benefit of the American people. At the close of the workshop, the panel members provided the following summary:

- To date, management to maintain separation between cattle and bison appears to be effective at preventing transmission of brucellosis between these species because no documented transmission has occurred under the Interagency Bison Management Plan.
- The best available data do not support that vaccination of wild bison with currently available vaccines will be effective at suppressing brucellosis to a level that changes bison management strategies under the Interagency Bison Management Plan.
- Control of bison population size will likely include culling or removal as tools in the future, along with hunting. Past and current culling practices have not had an apparent effect on reducing the overall prevalence of brucellosis in the bison population.
- Intervention through contraception is not needed to achieve the current goals of the Interagency Bison Management Plan. Contraception could potentially be a valuable tool for brucellosis suppression, but the available data are insufficient to make a judgment at this time. Further research, combined with modeling to evaluate contraception for disease control, is needed.

Description of the Alternatives

Alternative A (the No Action Alternative) describes the current hand vaccination program (syringe delivery of Strain RB51 vaccine) that has been occasionally implemented at the Stephens Creek capture facility. Implementation of hand vaccinations would continue, but there would be no remote delivery of vaccine under this alternative. This alternative relies on capturing bison that move to the Reese Creek boundary area in northern Yellowstone, containing them within the fenced pastures in the Stephens Creek facility, individually handling each animal, conducting blood tests to determine past exposure to brucellosis, and vaccinating young, non-pregnant animals by injection. Since the implementation of the Interagency Bison Management Plan in 2000, the National Park Service has only implemented hand vaccination at the Stephens Creek capture facility in 2004 (111 yearling and calf bison), 2008 (24 yearling and calf females), and 2011 (149 yearling and calf bison, 2 adults).

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 calves and yearlings. Remote-delivery vaccination could occur from mid-September through November, and April through June, 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 an 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 in two areas during the July to August breeding season and disperse over 89,000 hectares of habitat during the remainder of the year. As bison disperse, the average group size decreases, making it easier for staff hiking, on horseback, or in vehicles to work in close proximity to bison from mid-autumn through spring.

Alternative C is similar to Alternative B, but also includes the vaccination of adult females. Vaccination of adult females provides two benefits not available under Alternative B. This alternative addresses problems associated with the apparent short duration of immune protection provided by the currently available vaccine (Strain RB51) through repeated (booster) vaccination of individual bison. It also could increase population-level immunity (resistance) against future brucellosis transmission by more quickly providing vaccine to a larger number of bison. Some evidence from experiments on captive bison has shown that vaccinating pregnant bison late in the pregnancy period can cause abortions. However, delivery of vaccine during the earlier stages of pregnancy has been shown to be low risk, especially for those bison that were previously vaccinated as young animals.

Adaptive Management (An Action Common to All Alternatives)
The Interagency Bison Management Plan incorporated an adaptive management framework to conserve a wild, free-ranging bison population, while concurrently reducing the risk of brucellosis transmission from bison to cattle. To improve progress, the IBMP agencies also approved adaptive management adjustments in 2008 that further described the circumstances for bison occupying habitats outside the park, established a precedent for minimizing the annual consignment of large numbers 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. This adaptive management process would be used under all alternatives in this Final Environmental Impact Statement to evaluate, and if necessary, modify actions before and during the implementation of any bison vaccination to facilitate effective outcomes, minimize adverse impacts, and reduce operational costs.

National Park Service Preferred Alternative
The National Park Service has identified Alternative A, No Action, as its preferred alternative based on substantial uncertainties associated with vaccine efficacy, delivery, duration of the vaccine-induced protective immune response, diagnostics, bison behavior, and evaluation of public comments. The National Park Service has identified that the implementation of park-wide remote vaccination at this time would likely not achieve desired results and could have unintended adverse effects to the bison population and visitor experience due to:

- Our limited understanding of bison immune responses to brucellosis suppression actions such as vaccination;
- The absence of an easily distributed and highly effective vaccine (e.g., 10-15% reduction in infection; short duration of immune protection; cannot vaccinate females in second half of pregnancy);
- Limitations of current diagnostic and vaccine delivery technologies (inconsistent vaccine hydrogel formulation; short rifle range; no rapid diagnostics for live animals);
- Effects of bison nutrition, condition, and pregnancy/lactation that lessen protective immune responses from vaccination;
- Potential adverse consequences (e.g., injuries; changes in behavior) to wildlife and visitor experience from intrusive brucellosis suppression activities (e.g., capture; remote vaccination); and
- Chronic infection in elk which are widely distributed and would almost certainly re-infect bison.

Consistent with the 2000 Interagency Bison Management Plan, Alternative A proposes to continue hand-syringe vaccination of bison at capture facilities near the park boundary and conduct monitoring and research on bison and brucellosis. Also, selective culling of potentially infectious bison based on age and diagnostic test results may be continued at capture facilities to reduce the number of abortions that maintain the disease.

Alternative A also includes the continuation of an adaptive management program, as described in the 2000 ROD for the IBMP and subsequent adaptive management adjustments, to learn more about the disease brucellosis and answer uncertainties, as well as to develop or improve suppression techniques that could be used to facilitate effective outcomes, minimize adverse impacts, and lower operational costs of efforts to reduce brucellosis prevalence in the future. Examples of monitoring and research projects that could be conducted as part of the adaptive management strategy to improve our adaptive management decision process include:

- Identifying the ecological factors that influence immune suppression and vulnerability to infection;
- Evaluating if multiple vaccinations (booster vaccination) within a given year or across years increases protection from clinical disease (abortions);
- Evaluating if late-winter vaccinations elicit sufficient immune responses that are protective the following year;
- Identifying methods that effectively increase vaccination coverage (i.e., the proportion of each age class that can be consistently vaccinated each year), and evaluating whether this level of coverage combined with the estimated efficacy of the vaccine is adequate to reduce the level of infection within the bison population;
- Validating active infection in selectively culled bison based on age and immune responses measured with standard screening tests;
- Evaluating the safety and effectiveness of alternate vaccines and delivery methods for domestic livestock and wildlife, including cost-benefit analyses of different options;
- Evaluating behavioral responses of animals subject to vaccine delivery methods to avoid deleterious effects;

- Evaluating whether there are genetic effects to bison as a result of selective culling practices (e.g., shipment to slaughter or quarantine) that are based on brucellosis exposure (e.g., presence of antibodies);
- Conducting social science studies about human values and attitudes towards the conservation of wildlife affected by brucellosis to improve the effective exchange of information and enhance collaborative decision making; and
- Holistically evaluating brucellosis infection in bison and elk throughout the greater Yellowstone ecosystem and considering landscape-level brucellosis management strategies.

The National Park Service would also continue to work with other federal and state agencies, American Indian tribes, academic institutions, non-governmental organizations, and other interested parties to develop holistic management approaches, monitoring and research projects that could be conducted to improve the adaptive management decision process, and better vaccines, delivery methods, and diagnostics for reducing the prevalence of brucellosis in bison and elk and transmissions to cattle.

The remote vaccination alternatives (B and C) are not recommended as preferred due to the low potential efficacy of the proposed program given the state of vaccine encapsulation and remote delivery technology, and the unknown yet potentially negative behavioral impacts to bison and, in turn, visitor experience (e.g., wildlife viewing). Methods for encapsulating vaccines into bio-absorbable projectiles under quality controlled production and consistently delivering the necessary dose of vaccine to bison using ballistic delivery or other systems need to be improved. In addition, little information is available to assess the potential unintended behavioral consequences to bison from repeated remote-delivery vaccination over time.

Summary of Environmental Consequences

Impacts to Yellowstone Bison

Under Alternative A, minor adverse impacts could result in the short term from injuries, infection, and stress sustained by bison during capture, confinement, physical restraint, and hand-syringe vaccination. Injured individuals could be more susceptible to predation and winter-kill following their release from captivity. Under alternative A, minor beneficial impacts could result from vaccinating a relatively small portion (1%) of the population. Impacts on reducing brucellosis transmission under Alternative A would be minor and beneficial impacts resulting from vaccinating young and non-pregnant bison and providing them with some short-term resistance against future brucellosis transmission. Under Alternative A, minor beneficial impacts could result if vaccinating young and non-pregnant bison provides them with some short-term resistance against future brucellosis transmission. Hand-syringe vaccination with SRB51 provides only modest immune protection against *Brucella abortus*, including a 50-60% reduction in abortions, 45-55% reduction in infection of uterine or mammary tissues, and a 10-15% reduction in infection at parturition. Under Alternative A, minor to moderate adverse impacts could result in the short and long term because confinement and feeding may lead to food conditioning, disease transmission, and disruption of traditional migratory patterns.

Under Alternatives B and C, minor adverse impacts would include those disclosed for Alternative A. In addition, the remote vaccination of young bison (Alternative B) and adult females (Alternative C) via biobullet could result in more tissue damage and a higher risk of bleeding and infection.

Under Alternative B, minor to moderate beneficial impacts could result in the long term from vaccinating a larger proportion (10%) of the population. However, bison will likely react (e.g., changes in behavior) to remote delivery, which could reduce the amount of animals vaccinated over time. Also, limitations of current remote delivery technologies (inconsistent vaccine hydrogel formulation; short rifle range) will reduce effectiveness. Moderate beneficial impacts on reducing brucellosis transmission could result in the short and long term if brucellosis prevalence in the population is reduced by about 40% due to a lower probability of transmission following vaccination. Under Alternative B, moderate beneficial impacts could result if vaccinating and booster vaccinating young and non-pregnant bison provides them with longer resistance against future brucellosis transmission. However, remote delivery of vaccine would likely induce less of a protective immune response than hand-syringe vaccination. Also, less than 10% of the population is likely to be vaccinated under this alternative. Moderate adverse impacts could result in the short and long term because confinement and feeding may lead to food conditioning, disease transmission, and disruption of traditional migratory patterns. Also, remote vaccination could alter bison behavior in a way that leads to avoidance of people, disruption of social bonds, and higher energy expenditures by some individuals responding to, and avoiding, the vaccine delivery teams. Minor to moderate beneficial impacts could result due to a reduction in future abortions by vaccinated young and adult female bison, and an increase in calving rates and population growth.

Under Alternative C, moderate beneficial impacts could result in the long term from vaccinating a larger proportion (29%) of the population. However, changes in bison behavior and the limitations of current remote delivery technologies will likely reduce the amount of animals vaccinated over time. Major beneficial impacts on brucellosis transmission could result in the short and long term if brucellosis prevalence in the population is reduced by about 66% due to a lower probability of transmission following vaccination. However, it is highly uncertain whether substantial brucellosis reduction can be achieved through remote vaccination given (1) our limited understanding of immune responses in wild bison to vaccination, (2) the absence of an easily distributed and highly effective vaccine, and (3) limitations of current diagnostic and vaccine delivery technologies. Under this alternative, major beneficial impacts could result if vaccinating and booster vaccinating young and adult female bison provides them with long-term resistance against future brucellosis transmission. Moderate to major adverse impacts could result in the short and long term because confinement and feeding may lead to food conditioning, disease transmission, and disruption of migratory patterns. Also, remote vaccination could alter bison behavior in a way that leads to avoidance of people, disruption of social bonds, and higher energy expenditures. Moderate to major beneficial impacts could result due to a reduction in abortions by vaccinated bison, and an increase in calving rates and population growth.

Under each alternative, negligible to major, adverse, cumulative impacts could result from (1) the capture, confinement, and feeding of bison in Montana, (2) unintended harvest effects on bison demography and behavior, (3) livestock operations reducing tolerance for bison in some areas, (4) housing development fragmenting habitat or contributing to aggregations of bison that increase disease transmission and concentrate herbivory, (5) unintended effects of road grooming and winter recreation in Yellowstone that alter bison energy expenditures and behavior, (6) road and facility construction that disturb bison and their habitats, and (7) vehicle strikes and behavioral disturbances by visitors. Negligible to major, beneficial, cumulative impacts could result from (1) the capture and vaccination of bison by the State of Montana that reduces brucellosis transmission risk, (2) increased tolerance for bison in Montana due to hunting and an administrative rule change that eliminated many economic barriers created by the brucellosis class system, (3) quarantine efforts that provide a source of live, brucellosis-free bison for relocation elsewhere, (4) grooming of roads in Yellowstone for winter recreation that save bison energy while traveling and provide better access to foraging habitats, and (5) visitors gaining an appreciation of bison that could result in enhanced support for their conservation as wildlife.

Other Impacts

Negligible to minor beneficial impacts could occur to other wildlife in the short and long term because fewer bison would be transmission vectors of brucellosis to other animals. Negligible to minor adverse impacts could occur in the short and long term from disturbance and displacement of other wildlife near the capture and vaccination operations for bison. Impacts would be more widespread for the park-wide remote vaccination alternatives. Also, some animals could be exposed to biobullets with vaccine that deflect from the intended bison target and fall to the ground and are eaten.

Negligible to minor beneficial impacts to federally threatened species (grizzly bears, lynx, and wolverines [proposed]) could result in the short and long term because fewer bison would be transmission vectors of brucellosis to these species. Negligible adverse impacts to grizzly bears, lynx, critical habitat for lynx, and wolverines are expected due to grizzly bears denning during most bison capture operations, and spatial separation between capture facilities and lynx and wolverine use areas. If these threatened species fed on a carcass of a vaccinated bison, it would be less of a source of brucellosis infection that carcasses infected with field strains of *Brucella*. Impacts would be more widespread for the park-wide remote vaccination alternatives, but remote vaccination activities would not occur in areas where bears are observed.

Minor to moderate adverse impacts to ethnographic resources could result in the short and long term because capture and vaccination operations are offensive to some American Indians and some tribes in general. Also, bison should not be consumed for 21 days after vaccination. Thus, vaccinated bison are held in the capture facility and not allowed to migrate into Montana where treaty harvests occur. Minor to moderate beneficial impacts could result if vaccination contributes to decreasing brucellosis prevalence, which in turn, could increase bison productivity and contribute to more brucellosis-free bison for harvest and transfer to tribal lands. Impacts from the remote vaccination alternatives could be more extensive and widespread.

Minor to moderate adverse impacts to human health and safety could result in the short and long term if humans (1) are accidentally exposed to the vaccine and/or become sick or injured during handling of vaccine and/or bison, or (2) consume meat that has vaccine residue in it. Minor to moderate beneficial impacts could occur if vaccination reduces the number of infected bison, and consequently, the exposure risk to humans most likely to encounter the bacteria (hunters, wildlife biologists, and veterinarians). Impacts could be more extensive and widespread from the implementation of park-wide remote vaccination. Also, it is uncertain how many hunters would be exposed to remotely vaccinated bison since these animals would not be held in captivity during the vaccine withdrawal time (when their meat should not be eaten).

Negligible to minor adverse impacts to visitor use and experience could result in the short term because visitors would not have access to about 800 hectares of the Gardiner basin. Also, some visitors would be annoyed about the handling, confinement, and vaccination of bison. Negligible to minor beneficial impacts could result because some individuals would appreciate attempts to reduce brucellosis prevalence in bison and the risk of transmission to cattle. Impacts could be more extensive and widespread from the implementation of park-wide remote vaccination. Remote vaccination would result in additional injuries, the marking of more bison, and more than likely, changes in bison behavior (avoidance of people) that reduce visitor viewing opportunities. Impacts could be beneficial for visitors that support the protection of Montana's cattle industry and maintaining its brucellosis class-free status.

Negligible to minor adverse impacts to park operations could result in the short and long term from maintenance needs to keep the capture facility in good repair, staffing needs to support the hazing, capture, vaccination, and monitoring of bison, and staff time and effort to respond to requests from other agencies, media, tribes, and stakeholder groups or individuals. Negligible to minor beneficial impacts could result from providing new information that increases understanding of the implications and effects of managing and vaccinating bison, which could be used to address social conflicts related to bison. Impacts would be more extensive and widespread due to the use of park-wide remote vaccination. Some park staff would be required to learn and implement new skills and technologies. Also, there could be occasional traffic delays due to remote vaccination. In addition, there would be additional levels of inquiry, increased reporting requirements, and additional duties by some park staff related to vaccine encapsulation.

The Environmentally Preferred Alternative

The environmentally preferable alternative is the alternative that causes the least damage to the biological and physical environment. Also, it is the alternative which best protects, preserves, and enhances historic, cultural, and natural resources. National Park Service staff identified Alternative A—No Action—as the environmentally preferable alternative. Alternative A would cause the least damage to the biological and physical environment by conserving a large, wild, and genetically diverse population of bison and preserving important natural aspects and behaviors of this historic and iconic population by minimizing human intervention and unintended consequences resulting from remote vaccination. Alternative A also includes an adaptive management process to answer uncertainties, make improvements, and attain reasonable assurances of success for decreasing the prevalence of brucellosis in bison while protecting and preserving the historic, cultural and natural resources of the park.

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List of Acronyms

CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
DEIS	Draft Environmental Impact Statement
EIS	Environmental Impact Statement
FEIS	Final Environmental Impact Statement
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
FWS	U.S. Fish and Wildlife Service

Chapter 1: Purpose of and Need for Action

1.1 Introduction

The National Park Service (NPS) is considering implementing a remote delivery (see Glossary) vaccination program for free-ranging bison (*Bison bison* or *Bos 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] 2000a,b).

Yellowstone Bison

The Yellowstone bison population is comprised of plains bison that historically occupied about 20,000 square kilometers 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 bring back the population (Meagher 1973), and in summer 2013 there were about 4,600 bison in the park following calving. These bison are managed as wildlife in several large herds that move across an extensive landscape (89,000 hectares). The bison are subject to natural selection factors such as competition for food and mates, predation, and survival under substantial environmental variability (Plumb et al. 2009). As a result, they have likely retained the adaptive capabilities of plains bison.

Yellowstone bison contribute an important genetic lineage to plains bison that is not found elsewhere, except in populations started with bison relocated from Yellowstone (U.S. Fish and Wildlife Service [FWS] 2007, Halbert and Derr 2008, Dratch and Gogan 2010). They have high genetic diversity compared to many other populations of plains bison, and are one of a few bison populations with no evidence of potential cattle ancestry (Halbert 2003, Halbert and Derr 2007). They consist of a single population with two primary breeding herds: central and northern (Halbert et al. 2012). Most females return to the same breeding range each year, but males commonly move between the herds and contribute to gene flow between them (Gardipee 2007, White and Wallen 2012). Also, there has been an apparent increase in movements (dispersal, emigration) of females and gene flow between the two breeding herds since 2007 (White and Wallen 2012). Management for 3,000 to 3,500 bison in the population, with at least 1,000 bison in each breeding herd, should preserve more than 95% of existing genetic diversity over hundreds of years (Pérez-Figueroa et al. 2012).

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 use habitats in the Yellowstone River drainage, which extends 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 (water content of snow pack) ranging from 30 to 2 centimeters in the higher and lower elevation portions of the range, respectively (Farnes et al. 1999). Upland grasses comprise the majority of bison diets in northern Yellowstone, followed by sedges and rushes (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 degrees Celsius (Meagher 1973, Farnes et al. 1999). This area contains many moist meadows with grasses, sedges, and willows, as well as 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 mix with the northern herd before returning to the Hayden Valley for the subsequent breeding season (Geremia et al. 2011).

Counts of bison varied widely during 1985-2012 because many bison that left the park in winter were harvested or culled (White et al. 2011). Counts of the central herd decreased from 3,062 to 1,399 bison during 1995-1998, increased to 3,531 bison by 2005, and decreased to about 1,400 bison in 2013. Counts of the northern herd decreased from 1,140 to 455 during 1994-1997, but then increased to about 3,200 bison during 2013. This increase was facilitated by movements of bison from the central herd and possibly decreased competition as numbers of elk (*Cervus elaphus*) occupying the range decreased from about 19,000 counted individuals in 1994 to fewer than 4,000 counted individuals in 2013 (Bruggeman et al. 2009c, Plumb et al. 2009; Northern Yellowstone Cooperative Wildlife Working Group, unpublished data).

Bison began to seasonally migrate and expand their winter range onto lower elevation areas along the boundary of Yellowstone National Park and into Montana as numbers increased during the 1980s and bison began to experience nutritional shortages (Meagher 1989, Taper et al. 2000, Coughenour 2005, Bruggeman et al. 2009c). These movements allow bison to access food resources that are more readily available in areas of their range with lower snow depths. The livestock industry is concerned about bison transmitting brucellosis to cattle when they migrate outside the park during winter and spring (Cheville et al. 1998). Management of bison as wildlife on habitat outside Yellowstone is under the jurisdiction of the State of Montana.

Brucellosis in Wildlife

Brucellosis is a contagious disease caused by various species of bacteria (*Brucella*) that infects domestic animals, wildlife, and humans worldwide. The primary wildlife hosts in North America are bison and elk (*Brucella abortus*), caribou (*Brucella melitensis*), reindeer (*Brucella suis*), and swine (*Brucella suis*). The primary livestock hosts are cattle (*Brucella abortus*), goats (*Brucella melitensis*; Mexico only), swine (*Brucella suis*), and sheep (*Brucella ovis*). Brucellosis also occurs in carnivores (meat eaters), including dogs, and is usually caused by *Brucella canis* (Cheville et al. 1998). *Brucella abortus* is the only species of *Brucella* that has been identified in bison, cattle, elk, and other wildlife species in the greater Yellowstone ecosystem (GYE; Thorne et al. 1997, Cheville et al. 1998, Kreeger 2002).

In ungulates, transmission of *Brucella abortus* typically occurs through ingestion of live bacteria. The incubation period (time between exposure and onset of infection) for the *Brucella* bacteria varies widely depending on the amount of bacteria an animal is exposed to and the animal's age, sex, physical condition, stage of gestation, and whether or not it has been vaccinated against the disease (Nicoletti and Gilsdorf 1997). Abortion is the characteristic sign of brucellosis (Cheville et al. 1998). Other signs include retained placenta (membranes left in the uterus during labor), infertility, reduced milk production, lameness, and swollen joints (Rhyan et al. 1994, Olsen et al. 1997).

Brucellosis in Bison

The Yellowstone bison population was infected with the non-native disease brucellosis by European cattle or sympatric elk some time before 1917 (Tunnicliff and Marsh 1935, Meagher and Meyer 1994; M. Meagher, personal communication). Brucellosis can be transmitted between individuals of the Yellowstone bison population, and also between bison and elk, 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. Brucellosis can infect male and female bison regardless of age (Rhyan et al. 2009). The amount of bacteria shed by infected males is small and unlikely to transmit the disease (Lyon et al. 1995, Frey et al. 2013). However, females are more likely to shed an infective dose.

Transmission within the bison population occurs primarily when an animal that has never been infected or vaccinated ingests bacteria shed by an infected female on an aborted fetus, afterbirth, or other reproductive tract discharges (known as horizontal transmission; Figure 1; Williams et al. 1993, Rhyan et al. 1994). Infected mothers may also transmit *Brucella* bacteria to their young through sharing of blood during pregnancy or through milk when they are nursing (known as vertical transmission; Rhyan and Drew 2002).

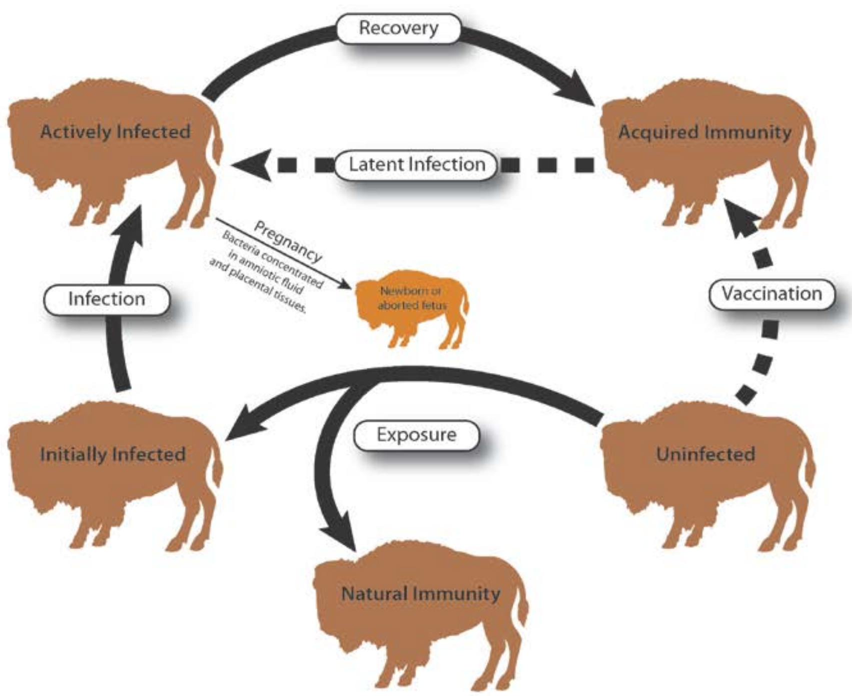

Figure 1. Brucellosis transmission cycle.

There is no treatment or cure for wild bison infected with *Brucella* (Cheville et al. 1998). In experimental animals, *Brucella* bacteria remained in their system for many weeks despite antibiotic treatments (Young and Corbel 1989). Some animals develop repeated infections and occasionally shed the bacteria throughout their reproductive life. Other animals may completely clear the bacteria. Natural resistance may occur in some bison since some cattle have a resistance to brucellosis that may be heritable (Templeton et al. 1988, Derr et al. 2002).

Brucellosis Transmission among Bison

When a bison ingests *Brucella* bacteria, specialized white blood cells from the bison's immune system recognize the bacteria as foreign material and ingest them (Nicoletti and Gilsdorf 1997, Grovel and Moreno 2002). The bacteria are then transported to tissues in the lymphoid system, which is part of the immune system. The immune system consists of a network of cells, tissues, and organs working together to defend the body against attacks by foreign substances. A key part of the immune system is its ability to distinguish between normal cells of the animal and foreign cells. Antigens are proteins on the surface of invading, foreign cells such as bacteria that identify them as invaders and trigger an immune response in the animal. During this response, the animal produces an antibody that binds to the antigen and marks the bacteria to be destroyed by the animal's immune system.

Some *Brucella abortus* cells survive this immune system response and remain inactive (dormant, latent) in lymph system tissues until conditions allow the bacteria to multiply and infect tissues and fluids associated with the developing fetus (Grovel and Moreno 2002). *Brucella* bacteria often increase in cells of the placenta during the middle and late stages of gestation and stimulate the production of hormones that mimic those at the initiation of parturition (Grovel and Moreno 2002). This hormone production results in abortions and bison calves born prematurely that are highly infectious due to a large number of *Brucella abortus* bacteria in the placenta and birth fluids. Aborted pregnancies and live births often attract the attention of other bison, some of which are susceptible (non-infected) and ingest the *Brucella* bacteria from birthing materials (amniotic fluids and placenta) or the newborn calf or fetus—thereby perpetuating the disease (Aune et al. 1998, Cheville et al. 1998). Following pregnancy, the *Brucella* bacteria may again become inactive, persisting in cells of the lymphatic system for a period before the animal becomes infectious again during a later pregnancy (Cheville et al. 1998, Galey et al. 2005).

The progression of brucellosis to the infective stage depends on when an individual is exposed to the disease (Rhyan et al. 2009, Treanor et al. 2011). Many bison are exposed early in life (less than 3 years old) before they are reproductively mature and can become pregnant (Treanor et al. 2011). The *Brucella* bacteria remain inactive in these bison until they become pregnant and conditions become favorable for bacteria to multiply and spread in the reproductive tract during the latter part of gestation (Grovel and Moreno 2002). However, the immune systems in these bison develop antibodies to the *Brucella* bacteria, which can attack the bacteria and possibly lessen the probability of abortion (Grovel and Moreno 2002). Conversely, bison exposed to *Brucella* bacteria during gestation can rapidly become infectious because conditions are favorable for bacteria to multiply and spread in the reproductive tract—thereby inducing abortions and premature live births (Grovel and Moreno 2002). The majority of animals appear to recover (clear the bacteria) from this infective phase, but some retain *Brucella* bacteria and can become infective during subsequent pregnancies (Rhyan et al. 2009, Treanor et al. 2011). Also, some animals could be re-exposed to a sufficient amount of *Brucella* bacteria on birthing materials at a later time and become infective again. However, the immune systems in these animals now have the ability to recognize the *Brucella* bacteria due to the previous infection, which could lessen the probability of subsequent abortions (Geremia 2011).

Brucellosis Infection Rates in Yellowstone Bison

The epidemiology, or spread, of brucellosis within the bison population is influenced by many factors, including the susceptibility of animals to infection and the amount of bacteria encountered by susceptible individuals (Williams et al. 1997, Thorne 2001). The quantity of *Brucella* bacteria shed, and the number of bacteria that comprise an infectious dose, both vary based on the vaccination history of individuals and their body condition at the time of shedding (Thorne 2001). Transmission increases with the number of aborted pregnancies within infected populations (Crawford et al. 1990, Cheville et al. 1998, Gross et al. 2002).

There is no rapid, reliable test to identify live bison capable of transmitting *Brucella* bacteria (Roberto and Newby 2007). Serology, which is a test to detect the presence of antibodies against a disease organism in blood serum (plasma), is used as an indication of past exposure to *Brucella abortus* bacteria. A positive serology test (seropositive) does not necessarily mean that the animal is still infected or capable of transmitting brucellosis bacteria (infectious).

Culture tests are used to identify *Brucella* bacteria in milk, lymphatic tissues, uterine discharges, and fetal tissues (Nielsen and Duncan 1990, Cheville et al. 1998, Thorne 2001). These tests generally require killing animals to obtain tissues for culture, and interpretation of results is difficult because culturing the bacteria depends on sampling tissues where bacteria are residing in the animal—which can vary over time (Nielsen and Duncan 1990). A positive culture of *Brucella* bacteria from tissue or blood is a definitive indication of infection, but a negative culture test does not necessarily mean that animal is not infected (Thorne 2001).

Forty to 60% of the Yellowstone bison population tests positive for antibodies in their blood indicating previous exposure to *Brucella* bacteria (Hobbs et al. 2013). However, only 25-46% of these seropositive bison test culture positive for *Brucella* bacteria, which indicates they are more likely to be infectious and shed live bacteria (Williams et al. 1993, Meyer and Meagher 1995, Roffe et al. 1999, Philo and Edwards 2002). Seropositive bison that are also culture positive in young age classes (less than 5 years old) pose the greatest risk for shedding *Brucella abortus* when they become reproductively active (Meyer and Meagher 1995, Roffe et al. 1999, Rhyan et al. 2009, Treanor et al. 2011).

Brucellosis in Humans

In humans, brucellosis is known as undulant fever. Though debilitating, undulant fever is rarely fatal. Human brucellosis in North America may be caused by *Brucella melitensis* in northern Canada and Mexico, *Brucella suis* in the southeastern United States, or *Brucella abortus* in the GYE. Transmission to humans is through ingestion, contact with mucous membranes such as the eyes, through an open wound, or by direct contact with skin (Young and Corbel 1989). Infected bison and elk in the GYE are a 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 towards eradication of brucellosis in livestock and pasteurization of milk, the national occurrence of undulant fever in humans from all *Brucella* species decreased from 6,500 reported cases in 1940 to 70 cases in 1994. The number of confirmed and probable brucellosis cases reported to the Wyoming Department of Health from counties surrounding Yellowstone ranged from 0 to 2 during 1991-2010 (http://health.wyo.gov/phsd/epiid/brucellosis.html). In Montana, there have been two confirmed cases of hunters contracting undulant fever from elk

(Greater Yellowstone Interagency Brucellosis Committee 1997). We are not aware of any Yellowstone visitors that have contracted the disease.

Disease Control via Vaccination

Long before the causes of disease and recovery were known, observers discovered that individuals who became infected and then recovered from a disease appeared more resistant (immune) to the same disease during a second exposure (Maybury Okonek and Peters 2004). Vaccination is designed to mimic this natural process and provide animals with an acquired immunity (resistance) against disease, without exposing them to the full effects of the natural infection process. Vaccines are modified or weakened versions of disease organisms such as bacteria. When administered to previously uninfected animals, vaccines "teach" the immune system how to react to disease organisms that enter the body.

The immune systems of animals are composed of a variety of cells (white blood cells are the most common) and organs (spleen and thymus) that defend against infection and disease (Black 2005). Cells called macrophages are designed specifically for "eating" invading foreign substances (including vaccines) and presenting them to specialized white blood cells (lymphocytes) in the lymph nodes. This process stimulates the immune system to (1) activate more lymphocytes, (2) actively attack and destroy infected cells, and (3) secrete antibodies to bind with receptors on the foreign substances and render them non-functional. The immune system gradually eliminates the invading disease organisms and the infection disappears. Once the infection is eliminated, some of the lymphocytes are converted to memory cells that circulate in the body and enable the immune system to respond to subsequent infections more rapidly. In this manner, vaccination induces a weakened infection that is cleared by the immune system and leaves behind memory cells that enable an animal to fend against subsequent exposures to the natural strain of bacteria more effectively.

The spread of diseases requires infected and susceptible (non-infected) individuals. A disease should disappear when the number of susceptible individuals in a population decreases to a low level. Vaccination can contribute to disease elimination by reducing the number of susceptible individuals. However, vaccines rarely provide 100% protection against infectious diseases, especially organisms that invade the interior of individual cells such as *Brucella abortus* (Gandon et al. 2001). Immunity to intra-cellular diseases requires a reaction by specialized lymphocyte cells (T-cells) that disrupt the organism's ability to replicate (multiply) within an animal's cells and prevent it from invading new cells. If the animal cannot clear all the disease, then it may not be resistant (immune) to re-infection for the rest of its life and symptoms of the disease could again appear after a period of inactivity (called latent infection).

Even if latent infection occurs, however, vaccinated animals should still have a more rapid immune response that requires exposure to a larger amount of the disease organism to stimulate another infection compared to an animal that is not vaccinated. Consequently, vaccinated bison should shed much less infectious *Brucella abortus* bacteria and have fewer abortions than non-vaccinated bison that are infected and shed bacteria (Olsen et al. 2003, 2006). A decrease in the rate of abortions and shed bacteria should result in a decrease in the rate of brucellosis transmission among bison.

Vaccination of Wildlife

Natural diseases within wildlife populations may or may not have a substantial negative effect on their reproduction and survival (Schubert et al. 1998, Grinder and Krausman 2001, Hudson et al. 2002, Hanni et al. 2003). However, exotic (non-native) diseases have the potential to erupt quickly within a population and cause substantial negative effects. 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 most common tool for disease control in veterinary medicine is vaccination, with success largely determined by the effectiveness of the vaccine and the proportion of the population vaccinated (Plumb et al. 2007, Martins et al. 2009). 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 concept of wildlife vaccination dates back to the early 1970s when baits containing rabies vaccine were distributed to control the disease in red foxes (*Vulpes vulpes*). Since that time, vaccines have been distributed to fox and raccoon (*Procyon lotor*) in the United States for rabies (oral; Hable et al. 1991, Centers for Disease Control 2005); brushtail possum (*Trichosurus vulpecula*) in New Zealand for tuberculosis (aerosol and oral; Corner et al. 2001, Skinner et al. 2005); mongoose (*Herpestes auropunctatus*) in the West Indies for rabies (oral; Creekmore et al. 1994); elk in the United States for brucellosis (rifle; Herriges et al. 1989); raccoon in Canada for canine distemper (oral; Schubert et al. 1998); badger (*Taxidea taxus*) in the United Kingdom for tuberculosis (oral; Delahay et al. 2003); cheetah (*Acinonyx jubatus*) and black rhinoceros (*Diceros bicornis*) in Namibia for anthrax (rifle; Turnbull et al. (2004); and bighorn sheep (*Ovis canadensis*) in the United States for pasteurellosis (rifle; McNeil et al. 2000).

Vaccines are a relatively low risk method for effectively reducing the transmission risk of wildlife diseases. However, wildlife creates substantial challenges for disease control because of their widespread distribution and mobility on the landscape, and limited knowledge regarding how their immune systems react to vaccination. Also, substantial reductions in disease through vaccination are likely only feasible when a high proportion of the population can be vaccinated regularly (Martins et al. 2009). However, few methods are available for the delivery of vaccine to free-ranging populations (Wobeser 1994, 2002). Other important factors to consider when evaluating the feasibility of a vaccination program are the average age at which individuals are exposed to the disease, and the duration of any protective immune response provided by the vaccine. Vaccination is most effective when it occurs prior to the period when most animals are exposed. Attaining immunity for most individuals in a population through vaccination is complicated when individuals acquire an infection from their mother during gestation or nursing.

In accordance with Chapter 4 of NPS Management Policies (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 because the aim of the program is to cause a decrease in the abundance of an exotic or non-native species (*Brucella abortus*) that induces abortions in native wildlife species. 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 vaccinated animals produces fewer symptoms and is less contagious to other susceptible individuals that have not been exposed to the disease.
- Vaccinated animals will be contagious for less time, and shed fewer bacteria, than non-vaccinated animals when they are naturally exposed to the disease.
- 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 immunity leads to a low probability of infectious events that spread the disease to numerous animals ("super-spreader" events; Ebinger et al. 2011).

The IBMP includes definitions of safety (low risk) and effectiveness 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 federal and state agencies made the decision to vaccinate bison when a vaccine was shown to be low risk. A low risk vaccine has two components: protein or DNA derivative of disease and an effective delivery system (Brake 2003). 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 Strain 19 as the required vaccine for cattle and is also used for bison in the United States. Strain RB51 vaccine can be a useful tool for eradicating bovine brucellosis in well-controlled epidemiological units, provided that a high proportion of the population is vaccinated for a sufficiently long period of time, and vaccination is combined with an appropriate test-and-slaughter program after vaccination has been effective (Martins et al. 2009).

Methods for remote delivery of vaccine do not involve direct contact with humans. In general, these methods consist of, but are not limited to, air-powered rifles firing biobullets or darts, bait containing vaccine, and aerosol sprays mixed with feed. The two latter methods have not been developed and are not available for delivery of brucellosis vaccines.

1.2 Existing Condition

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, Geremia et al. 2011). Approximately 15 to 25% of the population is actively infected by brucellosis (Treanor et al. 2011, Hobbs et al. 2013). Therefore, movements of bison outside the park result in a risk of brucellosis transmission to cattle on overlapping ranges adjacent to the park (Cheville et al. 1998). Though this risk is small in most years and only occurs during a period surrounding birthing, it is tangible and increases as winter severity (length, snow depth) and the number of bison migrating outside the park increase (Kilpatrick et al. 2009, Schumaker et al. 2010). In 2000, the federal government and the

State of Montana signed the IBMP (also known as the Joint Management Plan) to coordinate bison management (USDI and USDA 2000a).

Alternatives for the IBMP were evaluated in two FEISs and RODs (federal and state) executed in 2000 — one approved by the Governor of Montana and the other approved by the Secretary of Agriculture and the Secretary of the Interior. The extent of the study area focused 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 from bison to cattle to protect the economic interests of the livestock industry in Montana (USDI and USDA 2000a). 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 hand-syringe vaccination as a management tool were evaluated in the FEIS for the IBMP, the environmental consequences of a park-wide, remote delivery (i.e., without capture) vaccination program were not (USDI and USDA 2000a).

In addition to vaccination of bison using syringes at capture facilities, the 2000 ROD for the IBMP gave the park responsibility for evaluating an in-park, remote-delivery vaccination program. The goal of the in-park vaccination program would be to deliver a low risk, effective vaccine to bison suitable for vaccination inside Yellowstone National Park to (1) decrease the probability of individual bison shedding *Brucella abortus*, (2) lower the brucellosis infection rate of Yellowstone bison, and (3) reduce the risk of brucellosis transmission to cattle outside the park. Along with the development of a low risk and effective vaccine, an effective remote vaccination program depends on the development of a system to deliver vaccine to bison without capturing them.

The IBMP "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 vaccination program is part of a phased-in management strategy described in the IBMP. Through adaptive management, the IBMP is designed to progress through a series of management steps for bison tolerance (acceptance) on public lands outside Yellowstone National Park during the winter when cattle are not present. The state currently allows hundreds of untested bison to migrate outside Yellowstone National Park and into Montana during winter to facilitate their conservation and enable public and tribal hunts (Montana Fish, Wildlife & Parks and Department of Livestock 2004). Actions (e.g., hazing, capture) are taken, as necessary, to maintain separation between bison and cattle (Interagency Bison Management Plan Members 2012).

The IBMP directed the agencies to vaccinate bison at capture facilities along the north and west boundaries of the park when a vaccine was shown to be safe (USDI and USDA 2000b). These criteria were met and a limited hand-syringe vaccination program has been occasionally 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). Because vaccination is most effective when it occurs prior to an animal being exposed to the disease, the 2000 ROD noted that calves and yearlings of both sexes would initially be the target of vaccination in bison.

However, adult female bison would be vaccinated if and when the agencies deemed a vaccine was low risk and effective. This document also stated that the agencies would deem a vaccine low risk and effective according to criteria established by the Greater Yellowstone Interagency Brucellosis Committee. The existing vaccination program was initiated after a review of study results showed that SRB51 vaccine met the safety criteria (Wallen and Gray 2003).

1.3 Purpose and Need

The purpose of the EIS is to evalutate the potential implementation of a remote-delivery vaccination program for bison within Yellowstone National Park to address NPS responsibilities as directed by the IBMP. The purpose and need for vaccination is to (1) decrease abortion events in bison due to the non-native disease brucellosis, (2) reduce the transmission of brucellosis among bison, (3) increase tolerance for untested bison on essential winter ranges in Montana when cattle are not present, and (4) reduce the need for capture and shipments of large numbers of bison to slaughter. Expanding the current bison vaccination program to include remote-delivery vaccination could further protect livestock from the risk of brucellosis infection, which could help to increase acceptance for bison that have not been tested for brucellosis to seasonally migrate outside Yellowstone National Park. The FEIS and ROD for the IBMP indicated that the release of untested bison outside Yellowstone National Park (i.e., Step 3 in the plan) would begin with the initiation of a vaccination program of bison inside the park with an effective remote delivery system. However, the 2000 ROD for the IBMP also states that "Additional 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 NEPA requirement and will result in a decision on whether to proceed with the implementation of remote-delivery vaccination of bison throughout Yellowstone National Park.

Chronic brucellosis infection does not adversely affect the long-term viability of Yellowstone bison (Fuller et al. 2007b, Geremia et al. 2009, Hobbs et al. 2013). However, it has prevented the use of their exceptional wild state and adaptive capabilities to contribute to the restoration of plains bison in the GYE and elsewhere (Freese et al. 2007, Sanderson et al. 2008, Gates et al. 2010). The following statements from the IBMP further establish the need and guidelines for vaccination of bison in the park:

- The NPS does not intend to conduct extensive capture operations in the interior of 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).
- The NPS will conduct a vaccination program of bison within the park "to allow a limited number of untested bison on winter range lands outside the park" (USDI and USDA 2000b:37).
- The vaccination program should contribute "to the eventual elimination of brucellosis from the Yellowstone bison" 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).

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

- Preserve the migration of bison across the park boundary onto essential winter ranges in Montana to facilitate the long-term conservation of bison.
- Decrease the probability of individual bison shedding *Brucella abortus* bacteria.
- Lower the brucellosis infection rate of bison.
- Reduce the risk of brucellosis transmission to cattle outside the park.
- Develop, test, and use a safe and effective system to deliver vaccine to bison.

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 decision from this analysis will be tiered from the decisions contained in the 2000 ROD for the IBMP. This EIS is not intended to revisit the IBMP or revise decisions approved by the 2000 ROD for the IBMP.

The analysis area for the program includes the area of bison distribution in the park (Figure 2). The proposed alternatives described in this analysis rely on using adaptive management to achieve results by (1) developing predictions based on modeling of the alternatives, (2) implementing management actions with subsequent monitoring, (3) adjusting management actions as necessary based on the monitoring results to improve effectiveness and minimize adverse impacts, and (4) continuing monitoring which could result in further adjustments to management actions (see Chapter 2 for further explanation).

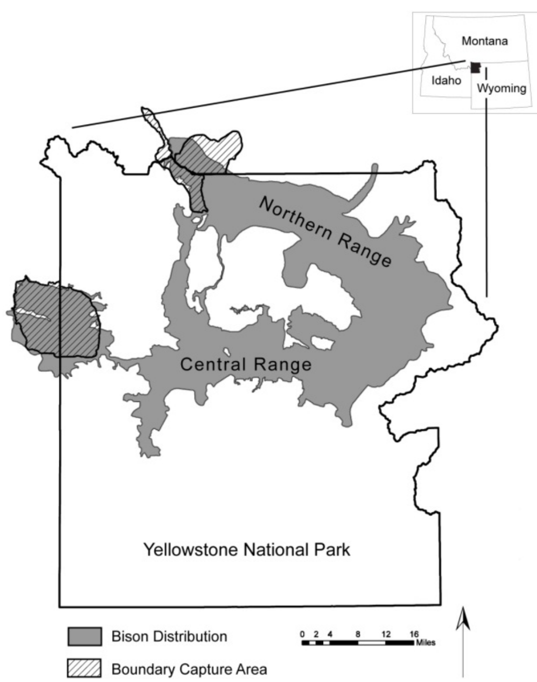

Figure 2. EIS analysis area.

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, 890,300 hectares 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 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).

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 A.

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).

Management Policies for the 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 project planning documents. 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. 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 (NPS 2006).

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 (Conservation Planning, Environmental Impact Analysis and Decision-making; 2009a) and its implementing handbook (NPS 2001) direct the planning process under 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 (USDI, FWS 2008a).

Natural Resource Management Reference Manual #77 offers comprehensive guidance to NPS 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 project planning documents, as guided by the application of the NPS Management Policies (2006). These planning documents require the protection of ecological processes and native species in a relatively undisturbed environment.

The IBMP 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 prevalence in bison and reducing the transmission of brucellosis from bison to bison and from bison to cattle. The FEIS and federal ROD for the IBMP 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 (USDI and USDA 2000a,b). The projected process was to begin vaccinating all eligible bison captured at the park boundary and subsequently release them. 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-population vaccination goal.

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. 2013). Progress has been slower than anticipated at completing the plan's successive adaptive management steps designed to 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 (White et al. 2011). 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 that relate to the management of bison in the GYE (Table 1). These planning efforts involve the NPS, other federal and state agencies, and American Indian tribes. 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 the NPS Management Policies (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.

Table 1. Relationships to other plans and documents.

Year	Plan/Document	Description	Requirements
2000	IBMP for the State of Montana and Yellowstone National Park	Separate RODs signed at federal and state levels.	The IBMP included remote vaccination in Step 3, 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 the 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 GYE, as appropriate.
2004	Final Bison Hunting Environmental Assessment	Prepared by Montana Fish, Wildlife & Parks. Assesses hunting for bison in Montana outside the park.	Decision notice in September 2004 authorized a fair-chase bison hunt in areas outside the park where direct hazing of bison was not occurring under the IBMP.
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 the vaccination of calves and yearlings as directed in the IBMP.
Year	**Plan/Document**	**Description**	**Requirements**
2004	Bison Quarantine Feasibility Study	Two Environmental Assessments prepared by Montana Fish, Wildlife & Parks and the Animal and Plant Health Inspection Service describe separate phases of the program.	Decision notices in January 2005 and June 2006 authorized a study to validate the quarantine protocol (proposed in Appendix B, IBMP).
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 & Parks.	Decision notice in December 2008 to purchase a livestock grazing restriction and enable some bison to occupy areas north of the park during winter.
2008	Bison Conservation Initiative	U.S. Department of Interior	Initiative to promote cooperative conservation in management by partnering with states, tribes, and others interested in bison recovery.
2009	Bison Translocation Environmental Assessment - Quarantine Phase IV	Prepared by Montana Fish, Wildlife & Parks.	Decision notices in 2009 and 2010 authorized the translocation and release of brucellosis-free Yellowstone bison from quarantine to the Wind River Indian Reservation in Wyoming (41 bison) and the Green Ranch in Montana (88 bison) for 5 years of further testing. Bison were never actually transferred to the Wind River Indian Reservation.

Year	Plan/Document	Description	Requirements
2010	Interim Rule—Brucellosis Class Free States and Certified Brucellosis-Free Herds; Revisions to Testing and Certification Requirements	Prepared by Animal and Plant Health Inspection Service.	Removed the automatic reclassification of any class-free state or area to a lower status if two or more herds were found to have brucellosis within a 2-year period.
2010	Brucellosis Remote Vaccination Program for Bison in Yellowstone National Park; DEIS	Prepared by the NPS.	Evaluated if remote-delivery vaccination of bison using available methods could substantially decrease the prevalence of brucellosis in the population.
2011	Call to Action Initiative	Director, NPS	Calls for restoring and sustaining three wild bison populations across the central and western United States in collaboration with tribes, private landowners, and other public management agencies.
2011	Executive Orders 1-2011 and 16-2011	Governor of Montana	The first order signed on February 15 prohibited the importation of bison into the state for 90 days. The second order signed on December 13 prohibited the transport of live fish and wildlife in Montana to or from any USDI-managed lands or facilities.
2011	Environmental Assessment for Interim Translocation of Bison	Prepared by Montana Fish, Wildlife & Parks to evaluate the feasibility of moving brucellosis-free bison that successfully completed quarantine to four locations on state or tribal lands.	Memorandum of understanding between Montana Fish, Wildlife & Parks and the Assiniboine and Sioux tribes of the Fort Peck Reservation signed in March 2012 authorized the translocation and release of 63 brucellosis-free Yellowstone bison from quarantine.
2012	Environmental Assessment for Adaptive Management Adjustments to the IBMP	Prepared by Montana Fish, Wildlife & Parks and Montana Department of Livestock.	Decision Notice in February 2012 approved increased tolerance of bison north of the park boundary.
2012	Directive from the Secretary of the Interior	U.S. Department of Interior	Directed consultation with tribes to evaluate opportunities for relocations of brucellosis-free Yellowstone bison to tribal lands. Directed the NPS to explore developing quarantine facilities for Yellowstone bison.
2013	Draft Joint Environmental Assessment: Year-round Habitat for Yellowstone Bison.	MFWP and the MDOL	An evaluation of the potential for year-round tolerance for Yellowstone bison in some areas near Yellowstone National Park.

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 Management Policies (2006:43) do not specifically mention vaccination, they do allow for “animal population management.” The use of vaccines for wildlife management and conservation purposes is not a new practice in NPS 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 numbers 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 could result in reduced transmission of brucellosis 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). There is no reason to think that remote 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 a sufficient number of animals (Wobeser 2002). However, many of the strategies used to manage wildlife diseases are complicated because it is impractical to capture or remotely deliver vaccine to all individuals in a population. Therefore, management of wildlife diseases is often limited to those that are zoonotic and can affect humans and their domestic animals.

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 NPS 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 affect park resources and values. Conversely, NPS activities may have impacts beyond the park 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 for bison is limited both inside and outside Yellowstone National Park. The court-mediated settlement (IBMP) between the NPS 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 population. Costs for vaccination were previously analyzed in the FEIS for the IBMP and further impact analysis for remote vaccination is disclosed in this EIS. Thus, the NPS finds that the remote vaccination of bison is an appropriate use at Yellowstone National Park.

1.9 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; Table 2).

Yellowstone Bison Population

The bison population is the key resource that may be affected by implementation of a remote vaccination program. 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 potentially 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 generally support vaccination as a way to reduce the risk of transmission of brucellosis from bison to cattle.

The effectiveness of SRB51 vaccine against field strain *Brucella 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 *Brucella abortus*, while 62% of bison that were not vaccinated aborted their pregnancies (Olsen et al. 2003). Conversely, experiments conducted by Texas A&M University concluded that repeated vaccination of adult and calf bison with SRB51 provided no protection from aborted pregnancies (Davis and Elzer 1999, 2002; Elzer et al. 2000). The results are not comparable, however, because methods were not consistent. The Scientific Advisory Subcommittee on Brucellosis for the United States Animal Health Association, which includes the authors of these various studies, reviewed the findings and concluded that 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 at parturition (Plumb and Barton 2008). The Subcommittee also indicated that currently available data suggests remote delivery of vaccine would likely induce less of a protective immune response than hand vaccination.

Other Wildlife

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

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 FWS or the National Marine Fisheries Service on any action that may affect threatened or endangered species or result in modification of designated critical habitat. Yellowstone National Park is occupied by the federally threatened Canada lynx and grizzly bear. Also, designated critical habitat for the Canada lynx includes portions of Yellowstone National Park. The bald eagle, peregrine falcon, and gray wolf occupy Yellowstone National Park, but were recently removed from the Federal List of Endangered and Threatened Wildlife and Plants. The Bald Eagle Protection Act still prohibits, except under certain specified conditions, the taking, possession, and commerce of bald and golden eagles. Consultation on Canada lynx and grizzly bear with respect to Section 7 for this EIS occurred with the FWS and concurrence with the NPS determination of "may affect, not likely to adversely affect" for species listed as threatened or endangered was received from the FWS in January 2007. In 2013, the FWS proposed to list the wolverine as a federally threatened species. At this time, no additional consultation is required for the wolverine.

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 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.

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 vaccinated bison. In addition, waste associated with vaccines and delivery methods may 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 portion of the Yellowstone bison population each year. It takes about 21 days for SRB51 vaccine to clear an animal's system. Meat from animals vaccinated with SRB51 should not be consumed at least until after this time period has elapsed.

Table 2. Environmental issues and corresponding impact topics.

Description of environmental/other issues	Chapter (section) where issue/impact discussed
Scientific evidence to support transmission of brucellosis between bison and cattle.	Chapter 1 (Introduction)
Effectiveness of vaccines.	Chapter 1 (Introduction); Appendix F (Inconsistencies and Uncertainties)
Safety and effectiveness of delivery methods.	Chapter 4 (Impacts to Yellowstone Bison); Appendix F (Inconsistencies and Uncertainties)
Modeling the probability that a vaccination program will successfully decrease the rate of brucellosis in bison.	Chapter 4 (Impacts to Yellowstone Bison);); Appendix F (Inconsistencies and Uncertainties); Appendix G (Vaccination Strategies for Bison)

Description of environmental/other issues	Chapter (section) where issue/impact discussed
Effective immunity against challenge with an infectious *Brucella* pathogen.	Chapter 2 (Alternatives Considered But Eliminated From Further Consideration); Appendix F (Inconsistencies and Uncertainties)
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 A (Compliance with Federal or State Regulations)
Visitor and aesthetic experience.	Chapters 3 and 4 (Visitor Use and Experience)
Human health and safety.	Chapters 3 and 4 (Human Health and Safety)
Impacts to the environment.	Chapter 4 (Impacts to Yellowstone Bison; Other Wildlife, Including Threatened Species)
NPS responsibility under the Organic Act of 1916 and National Environmental Policy Act.	Appendix A (Compliance with Federal or State Regulations)
American Indian tribal concerns and consultation.	Chapter 3 (Ethnographic Resources); Chapter 4 (Ethnographic Resources); Appendix A (Compliance with Federal or State Regulations)
The appropriateness of vaccinating wildlife against non-native diseases in national parks.	Chapter 1 (Introduction)

Visitor Use and Experience

The 1916 NPS Organic Act and the NPS Management Policies (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 beliefs that management actions to manipulate wildlife in national parks should not be undertaken. Therefore, vaccination activities could impact visitor experience.

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 implementation of a remote vaccination program in the park due to increased staff duties in providing field logistics, coordination with contractors for supplies and materials, and filling information requests by interested parties.

1.10 Topics Dismissed from Further Consideration

Council on Environmental Quality regulations (40 Code of Federal Regulations [CFR] Parts 1500-1508) and Director's Order #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.

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 IBMP 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 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.

Socioeconomics

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 (USDI and USDA 2000a) and are incorporated by reference in this EIS. In 2000, the IBMP 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 C). The implementation of remote-delivery vaccination would cost approximately an additional $300,000 per year for at least 30 years, likely implemented with federal funding.

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 (wages, salaries, payroll benefits), and $201 million in value added (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 the remote vaccination of Yellowstone bison are unlikely to reduce the seroprevalence of brucellosis sufficiently (near zero) to eliminate the concerns 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 similar seropositive values in elk populations managed by the state—which are not under consideration in this EIS for vaccination—due to apparent increasing brucellosis transmission from elk to cattle during the past decade. Brucellosis will remain a concern for the livestock industry regardless of the outcome of a vaccination program for Yellowstone bison and such a program would likely have negligible impacts on social and economic factors affecting the livestock industry. Regardless, Montana's gross annual income from cattle sales has surpassed $1 billion five times in the past seven years, and cattle prices have been at record highs since 2010 (Lutey 2012).

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 such as depopulation and 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 brucellosis-free due to social and political barriers such as human safety and property damage concerns, depredation of agricultural crops, competition with livestock for grass, lack of local public support, and lack of funds for state management (Boyd 2003, Plumb et al. 2009, Salazar 2012). These issues were adequately addressed in the "Impacts to Socioeconomics" section of the FEIS for the IBMP, and the information is still valid. Thus, the NPS incorporates that analysis by reference (USDI and USDA 2000a) and further analysis was not included in this EIS.

Possible Conflicts with Land Use Plans, Policies or Controls

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

Cultural 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. Historic structures are material assemblies that extend the limits of human capability. Cultural landscapes are settings that humans have created in the natural world. Museum objects are manifestations and records of behavior and ideas that span the breadth of human experience and depth of natural history (NPS 1998).

The proposed vaccination program is not anticipated to involve subsurface ground disturbance. The surface disturbance of the undertaking would be similar to the natural movements of humans and animals across the landscape. There are several significant historic structures within Yellowstone National Park. However, none of the alternatives would affect these structures. 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. No museum objects would be affected by the alternatives.

Following guidance in the National Historic Preservation Act, Section 106 consultation with both the Wyoming and Montana State Historic Preservation Offices was completed in December 2006, with concurrence of the NPS determination that no historic properties will be affected by the proposed actions. (Appendix D).

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 FEIS for the IBMP (USDA and USDI 2000a), the federal agencies conducted government-to-government consultations with American Indian tribes, as described in Volume 1, Appendix H of that document. In the 2000 FEIS, the NPS concluded that, though Yellowstone bison are significant to many tribes, they are not a trust resource that would trigger a federal trust responsibility. Thus, the NPS does not manage Yellowstone bison as a trust resource for one or more specific tribes, and as such, no trust resources will be affected by the alternatives. However, the NPS continues to consult with tribes on bison management issues and to manage Yellowstone bison like other natural resources in the park for the benefit of all citizens of the United States.

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.

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 because most of the vaccination program would either occur in boundary capture facilities (hand-syringe vaccination) and/or travel corridors and upland grazing areas (remote vaccination).

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. Helicopter use is not proposed under any alternative in this EIS. In addition, the use of projectile devices, such as compressed air-powered rifles, would be short-term, barely audible, and thus, have negligible impacts to natural soundscapes. Therefore this topic was dismissed from further analysis.

Wilderness

The Wilderness Act of 1964 established the National Wilderness Preservation System. NPS Management Policies (2006) require that wilderness be unimpaired. There are no congressionally designated wilderness areas within the park, but portions of the park are recommended for wilderness designation. The actions proposed in this EIS would not have greater than negligible, short-term adverse impacts to wilderness character within the park. Therefore, this topic was dismissed from further consideration.

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. Therefore this topic was dismissed from further consideration.

Caves and Paleontological Resources
No caves or paleontological resources would be impacted by any of the alternatives.

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.

Floodplains and Wetlands
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.

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.

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.

Natural or Depletable Resource Requirements and Conservation Potential
None of the alternatives would involve the use of depletable (consumptive) resources.

Climate Change
The NPS Management Policies (2006) and Climate Change Response Strategy (2010) guide efforts in developing responses to climate change. Managers are encouraged to engage partners and use the best available science, including climate change science, to inform park planning and the implementation of cooperative solutions. However, managers are not held accountable for adverse impacts such as emissions that arise from external sources—particularly those of global dimensions—over which managers have no control.

Though climatologists are unsure about the long-term results of global climate change, it is clear that the planet is experiencing a warming trend that affects ocean currents, sea levels, polar sea ice, and global weather patterns. These changes could affect winter precipitation patterns and amounts in the park, but it would be speculative to predict localized changes in temperature, precipitation, or other weather changes due to the many variables that are not fully understood or currently defined. Therefore, the analyses in this document are based on past and current weather patterns and the potential effects of future climate changes are not discussed further.

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). 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 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 in a large proportion of the population. Also, understanding the appropriate time of year to vaccinate animals to stimulate a good immune response is important for success.
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, particularly if brucellosis prevalence in bison is significantly reduced from current levels.
3. Third, an effective vaccination program needs an effective monitoring strategy to assess progress. Since the detection of infectious individuals cannot be rapidly done in live bison, a comprehensive monitoring strategy must be implemented to track a wide variety of infection indicators. Currently, serology and culture results are key indicators that identify the probability an individual is, or soon will become, infectious.

2.2 Actions Common to All Alternatives

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).

Continuation of Conservation and Brucellosis Risk Management Actions

The conservation of Yellowstone bison has been relatively successful, with a restored population of more than 4,600 in summer 2013 (from 25 bison in 1902; Meagher 1973) that are managed as wildlife in multiple, large herds that migrate and disperse across an extensive landscape (Plumb et al. 2009). These bison are subject to a full suite of native ungulates and predators, other natural selection factors, and substantial environmental variability (White and Wallen 2012). The population is reproductively prolific and has shown remarkable resiliency to recover rapidly from decreases in abundance due to culling or natural mortality (Fuller et al. 2007b, Geremia et al. 2009, White et al. 2011). Yellowstone bison have a relatively high degree of genetic variation, which should be maintained for centuries with a fluctuating population size that averages 3,000 to 3,500 bison (Halbert 2003, Pérez-Figueroa et al. 2012).

The overall abundance of Yellowstone bison during the life-cycle of the IBMP (2001-2013), based on summer counts, was between 2,432 and 5,015 (average ~ 3,900; White et al. 2011, 2012b). Also, adaptive management adjustments to the IBMP during 2005-2012 increased the tolerance for bison on habitat in Montana beyond that identified in the 2000 decision document for the IBMP (USDI et al. 2008, Montana Fish, Wildlife & Parks and Montana Department of Livestock 2012). Though the risk of transmission of brucellosis from bison to cattle is low during most winters, it is tangible during the bison birthing period and increases as the bison population grows, snow pack increases, and as a result, more bison migrate outside the park to access forage (Kilpatrick et al. 2009, Schumaker et al. 2010). Thus, a deliberate risk management strategy such as the IBMP is necessary to maintain separation between bison and cattle. To date, no documented transmission of brucellosis from Yellowstone bison to cattle has occurred due, in part, to successful efforts by federal and state agencies to maintain separation between cattle and bison (White et al. 2011). Human intervention will also be necessary to manage bison that conflict with human society and cross geographic or social boundaries of acceptance in Montana (Montana Fish, Wildlife & Parks and Montana Department of Livestock 2012).

Acquiring immunity to brucellosis is more difficult biologically than for many other diseases because of the intracellular survival and infection mechanism exhibited by this bacterium. A realistic goal of a brucellosis suppression program is to reduce shedding of the *Brucella* bacteria. A level of immunity that limits the shedding of *Brucella* bacteria is worthy to strive for regardless of whether management procedures reduce infection prevalence in the short term.

Reducing the portion of infectious bison, while attaining a high level of population immunity, is the best approach for reducing brucellosis infection in Yellowstone bison over the long term. Population immunity is a term that represents the portion of individuals in a population that have developed resistance to a disease. This immune protection is typically gained through infection and recovery, or through vaccination which mimics this process without individuals becoming infectious. Approaches that target pre-reproductive females for vaccination, while removing reproductively active, likely infectious females may be effective at reducing brucellosis transmission by focusing on methods to reduce shedding of the bacteria (Treanor et al. 2010, 2011; Ebinger et al. 2011).

Monitoring Plan

The NPS has developed a monitoring plan (Appendix E, White et al. 2012b) to obtain timely and useful information for tracking the status and responses of Yellowstone bison and brucellosis prevalence to management actions and to measure whether desired outcomes are being met. This long-term monitoring and research program would enable the evaluation of the strength and duration of the immune response in bison following syringe and/or remote (biobullet) delivery or vaccine for brucellosis. It would 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 (harvest, culling), and prevailing ecological conditions (winter-kill, predation) impact these trends. In addition, results from the monitoring program and other research would 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). This information would be used by managers to determine what, if any, adaptive management adjustments are needed to conserve bison and reduce the risk of brucellosis transmission among Yellowstone bison and to cattle. The NPS would work with the other IBMP members, scientists, and stakeholders to implement monitoring activities conducted under field, captive, and laboratory conditions to collect empirical data for evaluating progress. All alternatives would 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).

The NPS may mark animals via biobullet or paint-ball gun during remote-delivery vaccination, and ear tags and/or pit tags implanted subcutaneously during hand-syringe vaccination at capture facilities. Even if Alternative A, No Action, is selected in the Record of Decision, the NPS may conduct additional research on remote vaccination technology and techniques as part of adaptive management. This marking would contribute to effective monitoring 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, brucellosis prevalence response to management actions, and detection method. As necessary, NPS staff may 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 likely infectious bison.

Adaptive Management Process

The USDI has codified and amended policies and procedures for compliance with NEPA (USDI, FWS 2008a). These regulations indicate bureaus should use adaptive management when long-term impacts of actions may be uncertain and future monitoring will be needed to make adjustments in subsequent implementation decisions. Adaptive management is a decision-making process whereby the impacts and effectiveness of an action are monitored, and the action is refined as information is accumulated to enhance progress towards objectives and minimize adverse effects (Williams et al. 2007). In other words, if desired outcomes are not being met, then management actions are reevaluated or altered to achieve them (Figure 4).

Adaptive management is based on the premise that uncertainties exist in resolving many resource management issues and, as a result, learning is valuable (Holling 1978, Walters 1986, Walters and Holling 1990). Through careful predictions and monitoring of management actions our understanding is improved and actions can be adjusted to better achieve desired outcomes. In other words, adaptive management offers a reasonable method for action in the absence of complete information (Thrower 2006). In fact, successful ecosystem management depends on adaptively adjusting actions because system components and processes are constantly changing and, as a result, there is substantial uncertainty regarding their response to management actions (Ruhl 2005).

The NEPA focuses on agencies making an informed choice by requiring consideration of all information regarding the impacts of a proposed action and its alternatives. The typical NEPA analysis tends to follow a planned action, but given it is a procedural act, NEPA provides the flexibility to incorporate adaptive management. Adaptive management aligns well with fully informed decision making and NEPA does not preclude its use if the original NEPA analysis adequately describes adaptive management (Ruhl 2005, Thrower 2006).

A NEPA analysis should identify the range of management adjustments that may be taken as part of an adaptive management approach in response to the results of monitoring or research and should analyze the effects of such actions. If the adjustments to an action are clearly articulated in the description of the alternative and fully analyzed, then the action may be adjusted during implementation without the need for further analysis (USDI, FWS 2008a). Though different philosophies exist regarding how adaptive management should be implemented, certain characteristics transcend successful programs, including (1) there are clear linkages among key steps such as identifying objectives, implementing monitoring, and adjusting management actions based on what is learned, (2) results from monitoring and assessment are used to adjust management decisions, (3) progress is made toward achieving management objectives, and (4) stakeholders are involved and committed to the process (Williams et al. 2007, U.S. Government Accountability Office 2008).

Stakeholder Involvement

The measure of how well adaptive management works is whether it meets environmental, social, and economic goals, increases scientific knowledge, and increases consensus among stakeholders (Williams et al. 2007). An adaptive approach engages stakeholders in all phases of a project, using mutual learning to reinforce collaborative management (Gregory and Wellman 2001). Stakeholders must be willing to work together in a group environment to plan specific courses of action. For a specific adaptive management strategy to work on the ground, stakeholders must support the strategy’s goals and objectives.

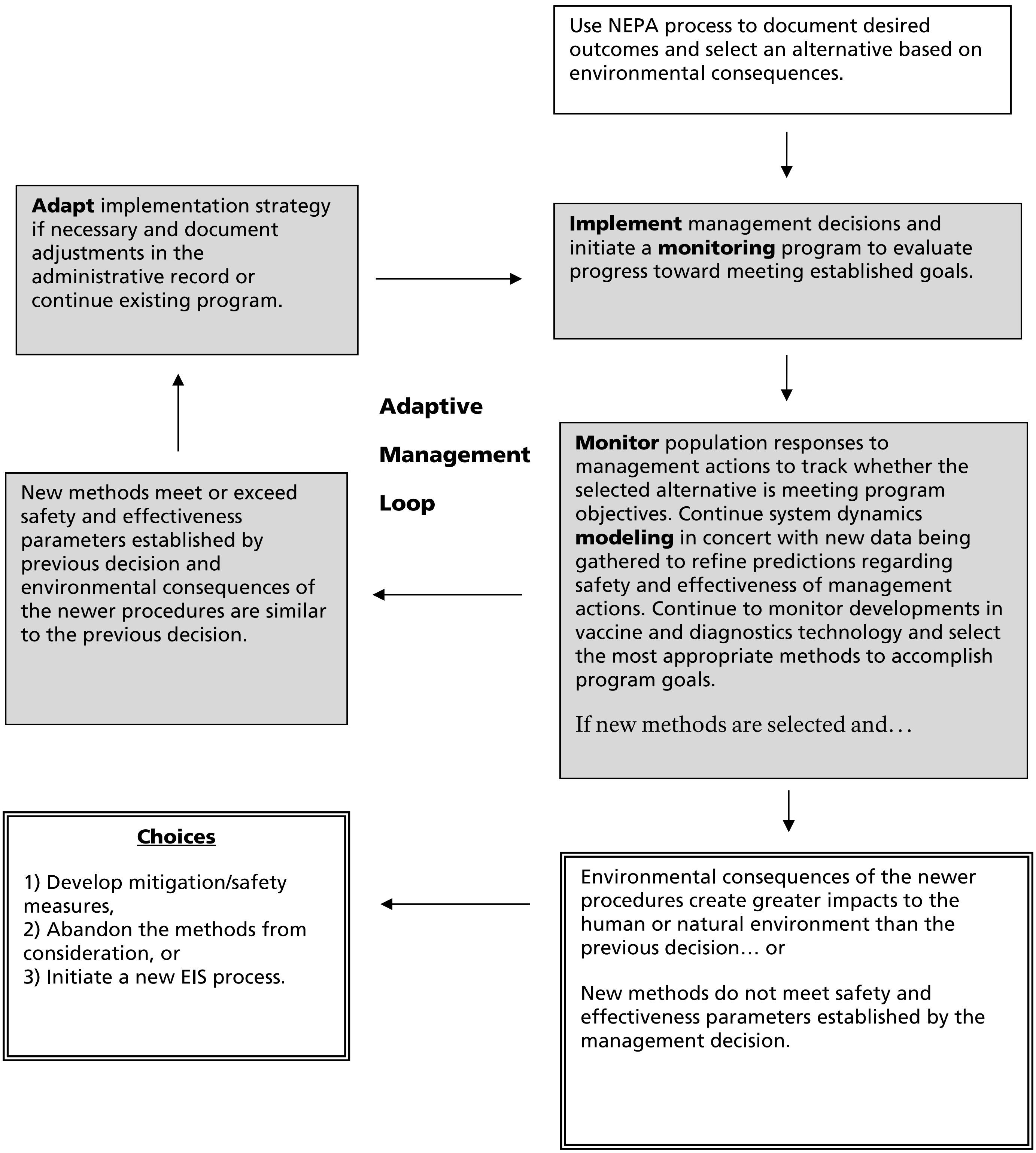

Figure 3. Adaptive management process.

The NPS and other IBMP members (Animal and Plant Health Inspection Service, Confederated Salish and Kootenai tribes, InterTribal Buffalo Council, Montana Department of Livestock, Montana Fish, Wildlife & Parks, Nez Perce tribe, U.S. Forest Service) have listened to and considered input regarding vaccination and other management activities from a diverse, citizen-formed working group that includes representation from livestock and bison conservation interests. The citizens working group made recommendations during 2011-2012 regarding bison restoration to other locations in the country, increased habitat for bison in Montana, bison population objectives to meet resource conservation goals, reduction in brucellosis prevalence, bison and cattle vaccination, and strategies for bison management consistent with the recognition of prevalence and risks associated with brucellosis in elk (Citizens Working Group on Yellowstone Bison 2011).

The NPS would continue to provide the other IBMP members, Citizens Working Group, and interested citizenry with periodic updates on bison and brucellosis prevalence. In addition, the NPS would make adaptive management adjustments transparent and accountable to these stakeholders by periodically (1) soliciting public comment on adaptive adjustments for consideration by decision-makers, (2) posting monitoring reports on the IBMP and park websites, (3) holding public information meetings, (4) publishing scientific and other articles, and (5) conducting other necessary analyses.

Models

In order to facilitate the adaptive management of bison and brucellosis, NPS staff would continue to collaborate with colleagues from academic institutions to develop models that characterize different ideas (hypotheses) about the dynamics of Yellowstone bison and brucellosis (in other words, how the system works). Currently, NPS biologists are working with Colorado State University to develop a model of the Yellowstone bison population and brucellosis by assimilating data from ongoing monitoring and designed studies of population and disease processes (Hobbs et al. 2013). The model portrays the dynamics of the bison population and the effects of brucellosis on its dynamics using variables representing different bison ages, sexes, and disease states. The model will be used to make short-term forecasts that quantify uncertainties associated with observations and the failure of models to portray the true state of the system (Hobbs et al. 2013).

In addition, staff from the NPS and University of Kentucky developed a model to evaluate how brucellosis infection might respond under alternate vaccination strategies, including (1) vaccination of female calves and yearlings captured at the park boundary, (2) combining boundary vaccination with the remote delivery of vaccine to female calves and yearlings distributed throughout the park, and (3) vaccinating all female bison (including adults) during boundary capture and throughout the park using remote delivery of vaccine (Treanor et al. 2007, 2010). This model was developed to enable direct comparisons of differences among vaccination alternatives, and necessarily was based on assumptions that reduced model complexity. Simulations suggested vaccinating all female bison (including adults) using both syringe and remote vaccination would be most effective, with brucellosis seroprevalence decreasing by 66% (from 0.47 to 0.16) over a 30-year period resulting from 29% of the population receiving protection through vaccination (Treanor et al. 2010). Under this scenario, bison would receive multiple vaccinations that extend the duration of the vaccine-induced protective immune response and defend against recurring infection in latently infected animals. The initial decrease in population seroprevalence would likely be slow due to high initial seroprevalence (40–60%), long-lived antibodies, and the culling of some vaccinated bison that were subsequently exposed to field strain *Brucella* and reacted positively on serologic tests (Treanor et al. 2010). The model showed vaccination is unlikely to eradicate *Brucella abortus* from Yellowstone bison, but could be an effective tool for reducing transmission (Treanor et al. 2010). Please note, however, that this model was not intended to make accurate, precise estimates of brucellosis suppression amounts and timelines due to uncertainty in parameters used to inform the models (e.g., weather, abundance of bison, and shifts in behavior in response to management actions). When uncertainty is included, predictive models often indicate large variation in expected outcomes, with far less confidence in achieving desired conditions (Hobbs et al. 2013).

Potential Outcomes, Management Actions, and Performance Metrics

Given the high uncertainty associated with brucellosis suppression actions, a hierarchical set of desired conditions was developed to represent a range of potential outcomes for vaccination in bison given the initial state of the system and proposed suppression actions (Table 3). These desired conditions and outcomes will guide decision making and evaluations of effectiveness. The most favorable outcome would be a 90% decrease in brucellosis seroprevalence from the current state (40-60%), which would decrease seroprevalence to approximately 5%—the same level as in Yellowstone elk. However, this outcome may be unattainable given the current state of vaccine efficacy and feasible delivery options for bison.

Table 3. Potential outcomes, management actions, and performance metrics for brucellosis suppression in Yellowstone bison.

<table>
<tr><th>Outcomes</th><th>Management Actions</th><th>Brucellosis Performance Metrics</th></tr>
<tr><td>Most Favorable
Decrease brucellosis prevalence to the level observed in Yellowstone elk</td><td rowspan="3">• Vaccinate eligible bison
• Selectively cull likely infectious bison based on serologic tests and age
• Brucellosis surveillance
• Brucellosis research
• Adaptively adjust management to improve effectiveness
• Target abundance for 3,000 to 3,500 bison through harvests, transfers of bison to tribes, and selective culls
• Maintain separation between bison and cattle
• Conserve migration and genetic diversity
• Increase tolerance for bison in Montana</td><td>• More than 50% of eligible bison vaccinated
• Decrease seroprevalence to less than 10% (assess prevalence changes in pre-reproductive age classes)
• Decrease the proportion of actively infected, reproductive bison (based on culture or serologic tests) to less than 5%</td></tr>
<tr><td>Moderate Reduction
Significant decrease in brucellosis prevalence</td><td>• 30-50% of eligible bison vaccinated
• Decrease seroprevalence to less than 30%
• Decrease the proportion of actively infected, reproductive bison to less than 15%</td></tr>
<tr><td>Status quo
No or minor decrease in brucellosis prevalence</td><td>• Less than 10% of eligible bison vaccinated
• Decrease seroprevalence by less than 50% from the current state (40-60%)
• Negligible to minor decrease in the proportion of actively infected, reproductive bison</td></tr>
</table>

A more realistic outcome from the vaccination program would be a 50% decrease in brucellosis seroprevalence from the current state, which would decrease seroprevalence to approximately 20-30%. The State Veterinarian for Montana indicated in comments on the DEIS for remote vaccination that such a decrease would alter perceptions of brucellosis transmission risk from bison to cattle and, presumably, lead to more tolerance for Yellowstone bison in Montana. Also, adaptive management adjustments would continue to be made in an attempt to increase effectiveness. A decrease in seroprevalence by less than 50% from the current state would be considered status quo and, as funding and other factors permit, research would be conducted to improve technology and techniques related to diagnostics, vaccines, and vaccine delivery.

Inconsistencies and Uncertainties

There are many inconsistencies and uncertainties associated with a park-wide bison vaccination program that make it extremely difficult to predict whether the desired outcome is achievable and sustainable, including (1) how effective will the vaccine be following delivery (including the duration of protective immune response), (2) how many bison need to be vaccinated each year, (3) how will bison behavior change in response to vaccine delivery, (4) how many injuries to bison will occur due to vaccine delivery, and (5) will there be increased tolerance for bison in Montana during and after vaccination? Similar uncertainties exist for all vaccination programs and Section 40 CFR 1502.22 of Council of Environmental Quality regulations and Section 4.5 of Director's Order #12 allows for a discussion of incomplete and unavailable information and how to include those data in analyses. Appendix F addresses this topic through (1) an explanation of incomplete or unavailable information, (2) an explanation of 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 in Chapter 4. Often uncertainty is expressed as disagreements among stakeholders who have differing views about the effects to resources from management actions. We have addressed these inconsistencies in the monitoring program and incorporated them into the adaptive management decision making process so that our understanding of the resource can be enhanced over time and management can be improved (Williams et al. 2007).

Three important assumptions are necessary for a vaccination program to be successful at contributing toward increased population immunity and consequently reducing the probability of infectious bacterial spreading events. There must be a consistent and sustained effort to vaccinate as many bison as possible from both the central and northern breeding herds each year (Treanor et al. 2010). Once vaccination is effective, there must be an effort to remove remaining likely infectious females following capture and testing in both park boundary management areas (Treanor et al. 2011). Consistent management support with funding to implement these strategies is imperative. Under the IBMP (2001-2013), vaccination and culling strategies have not been consistently implemented, which is likely the reason why there has not been a significant reduction in brucellosis prevalence (White et al. 2011). The nature of the IBMP partnership, whereby agencies contribute actions under their respective missions and jurisdictions, make the future successful implementation of these strategies uncertain.

Adaptive Management Adjustments

Moving forward with an effective vaccination program for bison in and near Yellowstone National Park depends on scientists within and outside the NPS addressing the inconsistencies and uncertainties identified by the U.S. Animal Health Association (2006) and others to improve the effectiveness of vaccines, vaccine delivery methods, and brucellosis testing. All of the discussion on incomplete and unavailable information (Appendix F) is relevant to evaluating reasonably foreseeable significant adverse impacts for the vaccination alternatives described in this document. Adaptive management could facilitate lessening these uncertainties and adjusting a plan to reach this desired condition by effectively linking models (predictions), monitoring and research (knowledge), and assessment of the effects and effectiveness of actions to objective-driven decision making (Williams et al. 2007). The adaptive management plan elements are limited only to those actions described here in the FEIS and approved in the Record of Decision for this EIS. The strong monitoring program that has already been used to effectively evaluate effects and effectiveness and make adaptive management adjustments to the IBMP would be continued regardless of the vaccination alternative pursued (White et al. 2012b). The adaptive management system is dynamic and needs to include not only the periodic evaluation of project performance, but also a reassessment of the objectives (Williams et al. 2007).

The efficacy of vaccine SRB51 has not been adequately tested on bison under field conditions and research is needed to estimate its efficacy within the Yellowstone system (Treanor et al. 2010). Also, the duration of the vaccine-induced protective immune response offered by SRB51 is unknown, but undoubtedly plays an important role in maintaining population immunity while reducing infection and transmission (Treanor et al. 2010). Yellowstone bison experience strong seasonal changes that cause stress and a reduction in nutritional condition. How bison respond to vaccination under these conditions will be important for estimating responses to *Brucella* exposure after vaccination (Treanor 2012). In addition, the biobullet delivery method needs further testing and improvement under experimental and field conditions on bison (Treanor et al. 2010). Additional research is needed to gain reliable knowledge regarding these uncertainties. In the interim, several assumptions were made to compare and evaluate remote-delivery vaccination alternatives, including (1) the efficacy of current *Brucella abortus* vaccine for bison will be intermediate between the levels identified in experiments (Davis and Elzer 1999, 2002; Olsen et al. 2003), (2) not all bison targeted for vaccine will receive a dose in any given year, and (3) not all vaccinated bison will exhibit a protective immune response (Treanor et al. 2010).

There are many research and monitoring activities that should be conducted before implementing remote vaccination of bison in Yellowstone National Park to determine with some certainty that (1) vaccination can be effective given existing constraints, (2) the desired outcome appears achievable and sustainable, and (3) there are assurances that the implementation of mass vaccination will contribute to a substantial increase in tolerance for Yellowstone bison in Montana. Examples of monitoring and research actions that may be conducted to improve our understanding of likely effects and inform the decision process include:

Vaccine delivery

- Evaluate the safety and effectiveness of alternate vaccines and delivery methods for domestic livestock and wildlife, including cost-benefit analyses of different options.
- Develop and test a 2-stage (vaccine plus booster) formulation using SRB51 vaccine, hydrogel polymers, and degradable biomedical microsphere encapsulation technology with the payload compartment of the degradable hydroxypropylcellulose Biobullet™. Within a single biobullet, this formulation would provide an initial rapid (days) release of live SRB51 vaccine from the gelled payload and, also, add a slower degrading micro-encapsulated SRB51 vaccine particulate booster that releases over weeks-months (Grainger 2011).
- Conduct shelf-life, ballistic durability, and re-hydration viability testing of the biobullet formulation.
- Develop standard operating protocols for production of vaccine-loaded biobullets that employ a quality control process to ensure standard methods and product specifications.

- Establish formal vendor supply-side and cooperative agreements to support the purchase, supply, testing, and production of the biobullet formulation, quality control validation, animal testing, and field testing necessary to execute a wildlife vaccine delivery project of this scope.

Vaccine efficacy and diagnostics

- Assess the level and duration of protective immune response following syringe and remote vaccination in controlled environments (captive facilities) and field studies.
- Identify the ecological factors that influence immune suppression and vulnerability to infection.
- Evaluate if multiple vaccinations (booster vaccination) within a given year or across years increase protection from clinical disease (abortions).
- Evaluate if late-winter vaccinations elicit sufficient immune responses that are protective the following year.
- Work with scientists to develop a polymerase chain reaction assay or other methods for potentially detecting active infection of *Brucella abortus* in live bison.
- Work with scientists to develop and test better vaccines for cattle and wildlife (DNA, Strain 82).
- Ensure bison vaccinated with SRB51 do not test seropositive for brucellosis exposure using the FPA test (evaluate Leal-Hernandez et al. 2005).
- Validate active infection in selectively culled bison based on age and immune responses measured with standard screening tests.

Portion of Bison Vaccinated each Year

- Refine models that describe brucellosis dynamics in Yellowstone bison and estimate the portion of eligible bison that must be vaccinated each year from each breeding herd to substantially reduce prevalence.
- Identify methods that effectively increase vaccination coverage (i.e., the proportion of each age class that can be consistently vaccinated each year), and evaluate whether this level of coverage combined with the estimated efficacy of the vaccine is adequate to reduce the level of infection within the bison population.
- Estimate the actual number of bison vaccinated (all methods) each year to assess the proportion of eligible candidates represented by the effort.

Bison Injuries and Behavioral Responses to Vaccination

- Assess bison behavior in response to captivity for syringe vaccination and simulated (such as paint balls) and actual (biobullets, darts) vaccination under free-ranging conditions.
- Assess bison injuries from hand-syringe and remote-delivery vaccination in controlled environments and field studies.
- Evaluate the effects of vaccinating pregnant females (perhaps with a lower vaccine dose) in the second half of gestation based on sero-status, vaccination history, age, and other factors.
- Evaluate whether there are genetic effects to bison as a result of selective culling practices (e.g., shipment to slaughter or quarantine) that are based on brucellosis exposure (e.g., presence of antibodies).

Tolerance for Bison in Montana

- Conduct social science studies about human values and attitudes towards the conservation of wildlife affected by brucellosis to improve the effective exchange of information and enhance collaborative decision making.
- Holistically evaluating brucellosis infection in bison and elk throughout the greater Yellowstone ecosystem and considering landscape-level brucellosis management strategies.
- Query the State of Montana for commitments to:
  - Conduct syringe vaccination of bison, and selective culling of likely infectious bison, at capture facilities outside the western boundary of the park using similar protocols to those used by the NPS at the Stephens Creek facility (north boundary);
  - Initiate remote vaccination of bison outside the park (per Step 2 of the IBMP);
  - Increase tolerance for bison on public lands in Montana;
  - Require the vaccination of all eligible cattle (including adulthood vaccination) in areas adjacent to Yellowstone; and
  - Modify hunting seasons, if necessary, to allow a sufficient withdrawal time following vaccination before bison may be harvested and consumed and/or harvest bison that are not vaccinated.

Adaptive management adjustments that could occur generally fall into four categories, including changes in vaccine, delivery method, and the timing of delivery, or discontinuing vaccination. Examples of management adjustments necessary to trigger adjustments to the vaccination plan during implementation based on monitoring and research information include:

Changes in vaccine

- Considering alternate vaccines such as (but not limited to) DNA vaccines and/or Strain 82 if lower risk and more effective vaccines than SRB51 are developed and tested for bison.

Changes in delivery method

- Considering alternate forms of vaccine delivery that are deemed effective, feasible, and low risk if research and monitoring indicates that vaccination in its implemented form is consistently injuring bison, altering their behavior, or not inducing a protective immune response in enough eligible bison to eventually achieve the desired outcome (at least a 50% decrease in brucellosis seroprevalence).

Changes in the timing of delivery

- Increasing the frequency of vaccination of eligible bison if assessments of the duration of immune protection (immunological memory) indicate individual bison need to be re-vaccinated to maintain a protective immune response through their lives.
- Changing the time of year delivery is implemented if evidence suggests a higher proportion of the population can be vaccinated or that a protective immune response is not being obtained.

Discontinuing vaccination

- Deciding whether to continue vaccination based on vaccine efficacy and the adequacy of delivery options to obtain the desired reductions in seroprevalence, transmission, and infection.

- Discontinuing vaccination if a minimum level of vaccine delivery such as greater than 50% of eligibles vaccinated cannot be obtained over a multiple year time frame.
- Discontinuing vaccination in its implemented form if there is no indication of progress (decrease in seroprevalence and infection in non-reproductive age classes) within 10-20 years, which is the approximate amount of time that may be required to determine how well the goals and objectives are being met (Ebinger and Cross 2008).

NEPA Sufficiency

The NPS would ensure that adaptive management adjustments, both individually and cumulatively, are (1) within the range of management adjustments described for the alternative selected in the Record of Decision, (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 (USDI, FWS 2008a). The following questions would be used to evaluate if this EIS adequately analyzes impacts for proposed adjustments to vaccination actions and applicable mitigation measures.

- Is the new proposed adjustment a feature of, or essentially similar to, an action or alternative analyzed in existing NEPA documents? Is the project within the same analysis area, or if the project location is different, are the geographic and resource conditions sufficiently similar to those analyzed in the existing NEPA documents? If there are differences, can you explain why they are not substantial?
- Is the range of alternatives analyzed in the existing NEPA documents appropriate with respect to the new proposed adjustments, given current environmental concerns, interests, and resource values?
- Is the existing analysis valid in light of any new information or circumstances (such as new scientific information about bison or brucellosis)? Can you reasonably conclude that new information and new circumstances would not substantially change the analysis of the new proposed action (including any new mitigation measures)?
- Are the direct, indirect, and cumulative effects that would result from implementation of the new proposed adjustments similar (both quantitatively and qualitatively) to those analyzed in the existing NEPA document?
- Are the public involvement and interagency review associated with existing NEPA documents adequate for the current proposed action?
- Has the proposed adjustment been discussed with stakeholders?
- Does the proposed action alter the conclusions of the no impairment determination appended to the original NEPA decision document?

2.3 Actions Common to All Remote Vaccination Alternatives

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 (interfering with body functions), causing changes in the demography (survival, reproduction) of the bison population, or creating behavioral disturbances (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 to increase population-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 *Brucella 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.

In May 1998, the Greater Yellowstone Interagency Brucellosis Committee developed the following guidelines that will be used to evaluate the safety and effectiveness of brucellosis vaccines for free-ranging Yellowstone bison. To be defined as safe, a vaccine would not significantly increase predation or decrease survival. Adverse effects such as listlessness, anorexia, depression, and arthritis that are short-lived and minimal with no long-term effects on survival may be acceptable. A safe vaccine will not be shed from a vaccinated bison prior to parturition. Persistence of the vaccine bacteria strain will not be associated with a significant reduction in the survival or reproduction of the individual such as repeated fetal loss, infected calves, or decreased fertility.

To be defined as effective in females, a vaccine must induce greater protection against fetal loss, infected calves, or infection in pregnant bison that are vaccinated compared to non-vaccinated bison. Infection is defined as either the number of bacteria colony-forming units per gram of cultured tissue or the number of infected tissues. 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 protective immunity induced by 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.

A major advantage of any vaccine would be the ability to differentiate vaccinated animals from those infected with *Brucella* field strains either by a serologic test or by alternate methods. A vaccine cannot cause deleterious effects on the short-term survival of other ungulates, rodents, carnivores, or avian species. Species that should be strongly considered for evaluation include bighorn sheep, elk, mule deer, pronghorn, coyotes (*Canis latrans*), wolves, ravens (*Corvus corax*), mice, and ground squirrels (*Spermophilus*).

Frequency, Location, and Method of Remote Delivery Operations

Remote-delivery vaccination of bison would occur during mid-September through November and, if necessary, April through June at widespread locations in the park (Figure 5). NPS staff would 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 movements via monitoring bison fitted with radio-telemetry collars has helped identify potential locations for 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 (cabins, trees, and rocks; Clarke et al. 2005).

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. As a result, it would likely take multiple days to vaccinate eligible bison within a given group.

2.4 Alternatives Considered

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

No in-park, remote-delivery vaccination operations would 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). Bison may also be vaccinated at the Duck Creek capture facility outside the western boundary of Yellowstone National Park and north of West Yellowstone, Montana. The current 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 via syringe. Currently, only calves and yearlings are vaccinated.

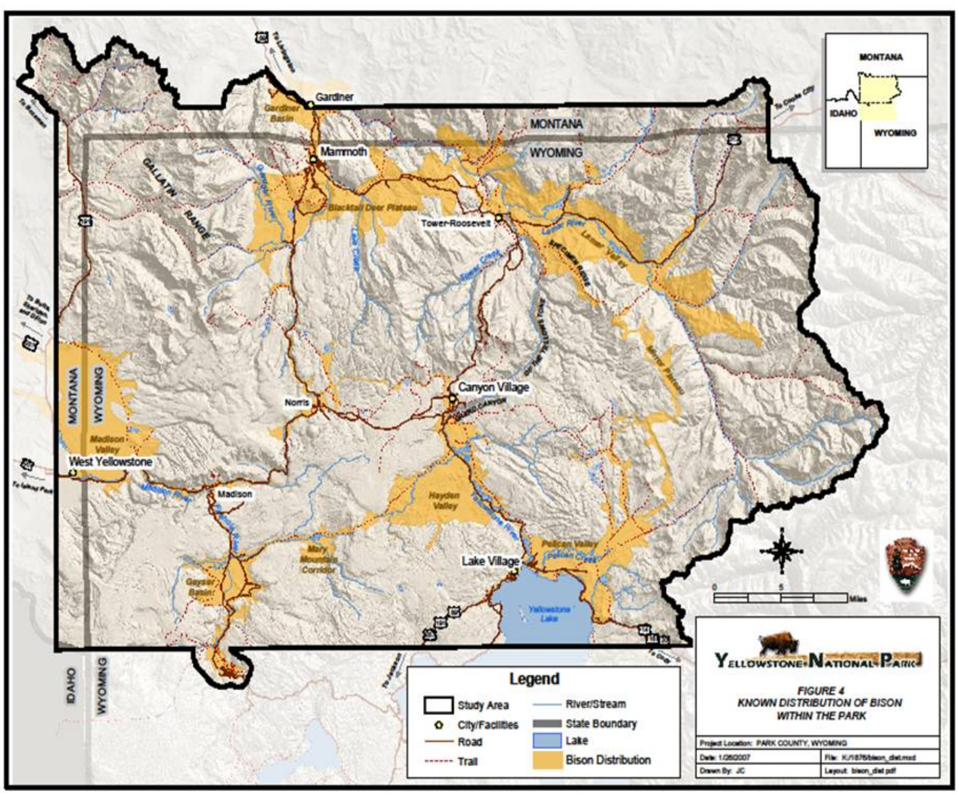

Figure 4. Known distribution of bison within Yellowstone National Park.

Under Alternative A, the IBMP members 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, brucellosis transmission risk from bison to cattle, new information or technology that reduces the risk of brucellosis transmission, and 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 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 *Brucella abortus* vaccine SRB51 is licensed for cattle, it has never gained label approval for bison. 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 (SRB51) for experimental study and evaluation.

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

- All vaccination operations inside Yellowstone National Park would occur at the Stephens Creek capture facility or during immobilization operations for research and monitoring (such as the fitting of bison with radio collars). Vaccination of bison at Stephens Creek typically occurs during a short time period (February and March).
- Staff involved in vaccination at Stephens Creek or immobilization operations would be limited in number.
- The NPS would order vaccine from a supplier when it is imminent that management operations would require vaccination of calves and yearling bison. Consequently, there would be little or no storage time at the capture facility.
- Staff would clean and disinfect areas where vaccine is mixed and used, and all individuals would wear sturdy rubber or latex gloves when handling the vaccine. Following work with the vaccine, all staff would wash with soap and hot water.
- For the safety of park visitors, an area closure would be enforced to keep park visitors from inadvertently encountering operations near the Stephens Creek capture facility. No visitors would be allowed near immobilization operations.
- The NPS estimates that fewer than 500 doses of *Brucella abortus* Vaccine, SRB51, Live Culture, Code 1261.00 (licensed product for use in cattle prepared by Colorado Serum Company) would be used each year. The product would 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 would 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 would reduce injuries.

  - Dominant, aggressive animals, such as large bulls, would be separated from smaller bison when animals are held at the capture facility. Filling pens with bison of similar age classes reduces injury risk due to confinement in small areas.
  - Monitoring of captive bison would be conducted daily to detect animals likely to abort or complete their pregnancy in the capture facility. These animals would be separated from the remainder of the group to protect against infectious shedding events.
  - All bison held in the capture facility would be provided adequate food and water.
- All syringes and needles used for vaccination would be sterilized to prevent infection.
- Vaccines would be given subcutaneously (under the skin) rather than in muscle tissue to reduce trauma.
- Vaccination at the Stephens Creek capture facility typically occurs in February and March. Few, if any, grizzly bears are likely to be in this area at this time. No Canada lynx or wolverines are expected to occupy habitats in this area. There is no designated lynx critical habitat in this area.
- The NPS would notify state wildlife agencies and American Indian tribes with recognized treaty harvest rights near Yellowstone of forthcoming vaccination efforts through established working groups and communications networks so that hunters can be cautioned not to consume the meat of a bison killed within 21 days of being vaccinated.
- The NPS may mark vaccinated animals via ear tags or pit tags implanted subcutaneously during hand-syringe delivery vaccination at capture facilities or field immobilization for subsequent monitoring to assess the extent of protective immune responses.
- A safety officer would be assigned to observe operations and recommend safety guidelines.
- The NPS would implement a health screening (i.e., medical monitoring) program for brucellosis exposure to biologists that handle vaccine and bison.

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 young bison inside 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 which should, in turn, induce a greater reduction in brucellosis prevalence, transmission, and infection.

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. Oral delivery is the most common method for vaccine delivery to wildlife. However, delivery to non-target animals (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").

There are no oral *Brucella abortus* vaccines available for use at this time. Currently, the most feasible method for remote delivery of brucellosis vaccine to Yellowstone bison includes the use of a compressed air-powered rifle with an absorbable projectile (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 to achieve more consistency with hydrogel formulation and encapsulation (Christie et al. 2006, Olsen et al. 2006; S. Olsen, unpublished data). 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 may 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, would be essential for maximizing remote delivery efficiency and success.

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 centimeters wide) and the shoulder (10-16 centimeters 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 (Alternative A). Brucellosis is maintained in the Yellowstone bison population primarily by young females which, for the most part, are born without infection but become exposed early in life (Treanor et al. 2011). Since female bison do not become reproductively active and contribute to brucellosis transmission until at least 3 years of age (Rhyan et al. 2009), there is an opportunity to implement management actions such as vaccination to reduce transmission potential (Ebinger et al. 2011).

Vaccination of calves and yearlings may occur during mid-September through November and April through June. Autumn delivery would provide vaccine to bison a minimum of 12 to 14 weeks prior to the anticipated dates of exposure to virulent field strains of *Brucella abortus*. This timing would also avoid aggressive, rutting bison in large groups during the late-summer months. In addition, 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 may 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 may 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.

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 biobullets. The distance of approach would be contingent on the behavioral response of bison. Approach to within a close distance (less than 30 meters) of the outer edge of a group of bison is generally possible during all times of the year. However, not all groups of bison respond similarly to human approach. Approaching 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.

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 vaccine to calves (both sexes) and adult and yearling females within 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 which should, in turn, induce a greater reduction in brucellosis prevalence, transmission, and infection.

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. 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 snow accumulates on 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 winter when energy conservation is important.

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

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

- Staff conducting remote delivery operations would move about the landscape in a deliberate, controlled manner to allow wildlife to detect their presence and react by either adjusting their location or remaining in place.
- The remote delivery projectiles would be 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.
- Bison would be vaccinated during autumn when animals are in prime condition and in spring when bison have access to highly nutritious forage to reduce the potential for trauma and vaccine-induced abortions. This strategy would also 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.
- The effective range of the biobullet delivery system would be determined and vaccine would be delivered from within this range to limit injury and potential indirect effects.
- Marked bison groups (such as animals with radio-telemetry collars) that have been remotely vaccinated would be monitored to determine the effects of vaccination on vital rates (survival, pregnancy) and the effectiveness of vaccination (including the duration of protective immune responses) to determine the safety and efficacy of the program.
- To help keep bison groups calm, staff would use slow and deliberate movements when approaching or working around groups of bison to deliver vaccine.
- Field staff with a good understanding of the vaccine delivery apparatus would receive intensive training to reduce the probability of poor shot placement.
- To ensure that projectiles do not carry non-*Brucella* bacteria, vaccines would only be used from approved manufacturers.
- Stainless steel remote delivery equipment, sealed vaccine projectiles, and radiated clips would be used to ensure the safest delivery of vaccine for bison and minimize any probability of infection at the injection site.
- All firearms would be equipped with trigger guards and safety switches to prevent accidental discharge.
- Equipment would be routinely cleaned and inspected to prevent accidental misfire or jamming of moving parts while a vaccine projectile is chambered.
- Staff would monitor a sample of vaccinated adult females to determine the probability of vaccine-induced abortions in bison. This data would 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 would notify state wildlife agencies and American Indian tribes with recognized treaty harvest rights near Yellowstone of forthcoming vaccination efforts through established working groups and communications networks so that hunters can be cautioned 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 to reduce the potential for multiple vaccinations of individuals within a season.
- NPS staff conducting remote-delivery vaccination would avoid working near wolf dens or locations where grizzly bears are known to be active. NPS staff would also avoid locations with ungulate carcasses that may be used by grizzly bears, wolves, or wolverines.

2.6 Alternatives Considered But Eliminated From Further Consideration

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 *Brucella abortus* bacteria currently found in the park environment. Use of this type of vaccine would prevent effective monitoring of a 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, which 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-population test and slaughter—to control brucellosis in bison. Studies have found that while 69% of pregnant bison vaccinated with Strain 19 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.

Delivery System that Results in Permanent Changes in Behavior or Demography

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 (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 individuals within bison groups. 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 in the interior of 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. 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. There could also be unintended consequences to the free-ranging nature of the bison population (long-term changes in bison behavior). The 2000 ROD for the IBMP and park policy allows this approach for animals that are near the park boundary and are captured at the Stephens Creek facility. However, the approach is contrary to the objectives of remote delivery to free-ranging animals.

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 (Clapp et al. 2011). 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 revert to virulence through mutation because they are not living organisms, nor 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. 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.

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). However, oral baits 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. There are no oral *Brucella 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 such as 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. 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 needle-less 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 consistent recommended dosage to a target population. In addition, the use of darts containing live *Brucella 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.

Buy Out Cattle in Yellowstone, Madison, and Gallatin River Valleys

This alternative would provide a means for reducing the risk of brucellosis transmission to cattle and address the larger issue of whether wild bison can be accommodated in Montana outside the currently negotiated conservation area boundary. However, the purpose and the need for action as defined in this analysis would not be met because buying out cattle would not decrease abortion events in bison due to the non-native disease brucellosis or reduce the transmission of *Brucella abortus* among bison. Also, the challenges to managing wild bison beyond the existing conservation area are more diverse (e.g., human safety, property damage) than simply preventing the mingling of bison with cattle during the brucellosis transmission period. These issues are beyond the scope of this analysis, which considers the vaccination of bison inside Yellowstone National Park.

The purchase of grazing rights or private lands for the benefit of wildlife conservation is a well-established model in North America and has been effective at procuring essential habitat for many decades. A key feature of success is when managing authorities collaborate and assume management responsibilities and stewardship of the habitat made available for the target wildlife. The state wildlife management agency or a coalition of conservation organizations are the likely candidates for leading this type of effort. The NPS would be supportive of efforts to secure additional bison habitat in the Yellowstone, Madison, and Gallatin River valleys through outright purchase of lands or conservation easements with willing sellers. The NPS has contributed financial support to assist IBMP members with developing effective conservation easements to increase bison habitat outside Yellowstone National Park.

Buying out cattle ranchers to cease cattle ranching on private lands in the Yellowstone, Madison and Gallatin River valleys would be an enormously costly venture and would not solve the debate about the extent of the conservation area boundary for bison near Yellowstone. Estimates of land costs in these valleys reach up to $15,000 per 0.4 hectare and the number of hectares that are currently occupied by ranching interests in these valleys is over a million. If a new conservation boundary is established to include these valleys, bison will eventually expand in numbers and distribution to occupy this available habitat and management practices to contain bison abundance and distribution would merely shift to new locations.

2.7 Consistency with the Purposes of NEPA

The NPS requirements for implementing NEPA include an analysis of how each alternative meets or achieves the purposes of NEPA, as stated in sections 101(b) and 102(1). CEQ Regulation 1500.2 establishes policy for federal agencies' implementation of NEPA. Federal agencies shall, to the fullest extent possible, interpret and administer the policies, regulations, and public laws of the United States in accordance with the policies set forth in NEPA (sections 101(b) and 102(1)). Therefore, other acts and NPS policies are referenced as applicable in the following discussion.

1. Fulfill the responsibilities of each generation as trustee of the environment for succeeding generations.

   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 conserve Yellowstone bison, and to the extent feasible, decrease the effects of infection by the non-native bacteria, *Brucella abortus*, which was introduced to the local environment nearly 100 years ago by domestic livestock. Thus, all alternatives promote preservation of native bison populations for future generations.

2. Ensure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings.

   All alternatives would essentially meet this purpose. No habitat modifications are proposed under any of the alternatives, there would be no changes to the types of recreational opportunities available, and most visitors would be generally unaware of bison management actions occurring under each of the alternatives. Alternative A would likely best meet this purpose as it would involve minimal human intervention and interaction with wild bison as compared to alternatives B and C that propose remote vaccination of large numbers of animals. However, the action alternatives would attempt to increase the number of bison that have vaccine-induced protective immune responses, and could result in the lowest potential for transmitting brucellosis to cattle outside of the park; thereby potentially increasing tolerance for wild-roaming bison outside of park boundaries. Within the park, however, remote vaccination activities and intense management of bison could alter perceptions of some visitors and may negatively affect their experience and surroundings—although in general most visitors would not be affected.

3. Attain the widest range of beneficial uses of the environment without degradation, risk of health or safety, or other undesirable and unintended consequences.

   Alternative A would best meet this purpose compared with action alternatives B and C due to the increased potential undesirable and unintended consequences to bison from remote vaccination under the action alternatives. Remote vaccination could cause changes to bison behavior and demography, as well as increased injury and potential for infection to individual bison. Under Alternative A, remote vaccination would not occur, and thus, would have the lowest potential for these negative consequences. Alternative A also includes an adaptive management program to answer uncertainties, make improvements, and attain reasonable assurances of success for decreasing the prevalence of brucellosis in bison. Additionally, Alternative A would have the lowest risk to human health and safety because of the reduced exposure to vaccines by staff and contractors. Under alternatives B and C, there would be a higher degree of human health and safety concern due to the increase in the number of vaccines handled which may result in a higher risk of injury from storage and preparation of the vaccination capsules in the remote delivery projectiles. Further, alternatives B and C also add an increased risk of health and safety due to an elevated "encounter probability" with bison when working in close proximity to the animals throughout their range. Because of the reduced likelihood of undesirable and unintended consequences, and the lowest risk to health and safety, Alternative A would best meet this purpose.

4. 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.

   All alternatives would preserve the important historic and cultural aspects of our national heritage in terms of historic structures and archeological resources, but also in terms of preservation of the historic and cultural aspects of the Yellowstone bison population. All alternatives propose to conserve a large, wild, and genetically diverse population of bison in Yellowstone and would serve to reduce the prevalence of brucellosis in wild bison. Alternative A would have less potential adverse impacts to individual bison, including injury and behavioral changes, as well as population-level impacts to demography resulting from remote vaccination. Alternative A would also minimize human intervention compared to alternatives B and C. However, Alternative C would maximize the number of bison that are vaccine-protected for a longer duration of time, and could result in the lowest potential for transmitting brucellosis to cattle outside of the park—thereby potentially increasing tolerance for wild-roaming bison outside of park boundaries. All alternatives would support diversity and individual choice.

5. Achieve a balance between population and resource use that will permit high standards of living and a wide sharing of life's amenities.

   All alternatives meet this purpose, but Alternative A best meets the purpose because it does not include remote vaccination that would potentially cause unintended negative consequences and would not promote more human intervention in bison management. It better achieves a balance between population and resource use by allowing for continued work towards reduction in the prevalence of brucellosis in bison, while minimizing the adverse impacts associated with remote vaccination. Alternative A also includes an adaptive management program to learn more about brucellosis and answer uncertainties, as well as to develop or improve suppression techniques that could be used to facilitate effective outcomes, minimize adverse impacts, and lower operational costs of efforts to reduce brucellosis prevalence in the future.

6. Enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

   All alternatives would meet this purpose and would equally enhance the quality of renewable resources through conservation of a large, wild, and genetically diverse population of bison in Yellowstone, and would serve to decrease the prevalence of brucellosis in wild bison. In addition, all alternatives would be equal in terms of approaching the maximum attainable recycling of depletable resources.

2.8 National Park Service Preferred Alternative

The “agency’s preferred alternative” is the alternative that the agency believes would fulfill its statutory mission and responsibilities, giving consideration to economic, environmental, technical and other factors (Question 4a of the CEQ’s “Forty Most Asked Questions Concerning CEQ’s NEPA Regulations” (1981)). To identify the NPS preferred alternative, discussions were held among NPS managers, scientists, and environmental specialists regarding the alternatives analyzed in the Draft EIS.

The National Park Service has identified Alternative A, No Action, as its preferred alternative based on substantial uncertainties associated with vaccine efficacy, delivery, duration of the vaccine-induced protective immune response, diagnostics, bison behavior, and evaluation of public comments. The National Park Service has identified that the implementation of park-wide remote vaccination at this time would likely not achieve desired results and could have unintended adverse effects to the bison population and visitor experience due to:

- Our limited understanding of bison immune responses to brucellosis suppression actions such as vaccination;
- The absence of an easily distributed and highly effective vaccine (e.g., 10-15% reduction in infection; short duration of immune protection; cannot vaccinate females in second half of pregnancy);
- Limitations of current diagnostic and vaccine delivery technologies (e.g., inconsistent vaccine hydrogel formulation; short rifle range; no rapid diagnostics for live animals);
- Effects of bison nutrition, condition, and pregnancy/lactation that lessen protective immune responses from vaccination;
- Potential adverse consequences (e.g., injuries; changes in behavior) to wildlife and visitor experience from intrusive brucellosis suppression activities (e.g., capture; remote vaccination); and
- Chronic infection in elk which are widely distributed and would almost certainly re-infect bison.

Furthermore, the NPS believes that implementation of remote-delivery vaccination could have unintended adverse effects to the bison population and the ability for a portion of the population to access conservation area lands beyond the park.

Under Alternative A, and consistent with the IBMP, the NPS would continue hand-syringe vaccination of bison at capture facilities near the park boundary to facilitate monitoring and research on the relationship between bison and brucellosis. Also, the selective culling of females, especially those previously exposed to brucellosis and pregnant for the first time (3 years old) and young mature female bison (4-5 years of age) that were recently infected, may be continued at capture facilities to reduce the number of abortions that maintain the disease (Treanor et al. 2011). Older adult females that have been exposed to the bacteria but recovered from acute infection could be retained in the population because their immune systems likely have some capability to recognize the pathogen and diminish the future probability of an abortion or infectious live birth, thereby reducing transmission within the population (Geremia 2011, Treanor et al. 2011).

Alternative A also includes the continuation of an adaptive management program, as described in the 2000 ROD for the IBMP and subsequent adaptive management adjustments, to learn more about the disease brucellosis and answer uncertainties, as well as to develop or improve suppression techniques that could be used to facilitate effective outcomes, minimize adverse impacts, and lower operational costs of efforts to reduce brucellosis prevalence in the future. Examples of monitoring and research projects that could be conducted as part of the adaptive management strategy to improve our adaptive management decision process include:

- Identifying the ecological factors that influence immune suppression and vulnerability to infection;
- Evaluating if multiple vaccinations (booster vaccination) within a given year or across years increases protection from clinical disease (abortions);
- Evaluating if late-winter vaccinations elicit sufficient immune responses that are protective the following year;
- Identifying methods that effectively increase vaccination coverage (i.e., the proportion of each age class that can be consistently vaccinated each year), and evaluating whether this level of coverage combined with the estimated efficacy of the vaccine is adequate to reduce the level of infection within the bison population;
- Validating active infection in selectively culled bison based on age and immune responses measured with standard screening tests;
- Evaluating the safety and effectiveness of alternate vaccines and delivery methods for domestic livestock and wildlife, including cost-benefit analyses of different options;
- Evaluating behavioral responses of animals subject to vaccine delivery methods to avoid deleterious effects;
- Evaluating whether there are genetic effects to bison as a result of selective culling practices (e.g., shipment to slaughter or quarantine) that are based on brucellosis exposure (e.g., presence of antibodies);
- Conducting social science studies about human values and attitudes towards the conservation of wildlife affected by brucellosis to improve the effective exchange of information and enhance collaborative decision making; and

- Holistically evaluating brucellosis infection in bison and elk throughout the greater Yellowstone ecosystem and considering landscape-level brucellosis management strategies.

The National Park Service would also continue to work with other federal and state agencies, American Indian tribes, academic institutions, non-governmental organizations, and other interested parties to develop holistic management approaches, monitoring and research projects that could be conducted to improve the adaptive management decision process, and better vaccines, delivery methods, and diagnostics for reducing the prevalence of brucellosis in bison and elk and transmissions to cattle.

2.9 Environmentally Preferred Alternative

The NPS is required to identify the environmentally preferable alternative in its NEPA documents for public review and comment. The NPS, in accordance with USDI NEPA Regulations (43 CFR 46) and CEQ's Forty Questions, defines the environmentally preferable alternative (or alternatives) as the alternative that best promotes the national environmental policy expressed in NEPA (section 101(b)) (516 DM 4.10). The CEQ's Forty Questions (46 FR 18026) (Q6a) further clarifies the identification of the environmentally preferable alternative stating, "this means the alternative that causes the least damage to the biological and physical environment; it also means the alternative which best protects, preserves, and enhances historic, cultural, and natural resources."

NPS staff identified Alternative A—No Action as the environmentally preferable alternative. This alternative would cause the least damage to the biological and physical environment by conserving a large, wild, and genetically diverse population of bison and preserving important natural aspects and behaviors of this historic and iconic population by minimizing human intervention and unintended consequences resulting from remote vaccination. Alternative A also includes an adaptive management process to answer uncertainties, make improvements, and attain reasonable assurances of success for decreasing the prevalence of brucellosis in bison while protecting and preserving the historic, cultural, and natural resources of the park.

Alternatives B and C propose to implement remote vaccination which may have an adverse effect on the natural behavior of bison, cause tissue injury to individual bison, and may cause other unintended consequences to the biological and physical environment. Therefore these alternatives, when compared to Alternative A, would not be environmentally preferable.

2.10 Future Surveys and Regulatory Compliance Necessary to Implement the Project

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 for the 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 would 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 may need to be completed to implement the project (depending on which alternative is selected for implementation):

- Application for, and receipt of, a permit from the Animal and Plant Health Inspection Service, Center for Veterinary Biologics, to package 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 vaccination program.
- Conduct or review the findings of experiments in controlled environments (quarantine, captive facilities) to determine the strength and duration of the protective immune responses in bison following hand-syringe or remote-delivery vaccination with SRB51 or new vaccines.
- Conduct field trials to determine the strength and duration of protective immune responses in bison following hand-syringe or remote-delivery vaccination with SRB51 or new vaccines.

2.11 Comparison of Alternatives

In accordance with the requirements of NEPA (42 USC § 4371 et seq.), Table 4 summarizes the chief features of each alternative in comparative fashion, Table 5 compares each alternative with the project objectives, and Table 6 summarizes the direct and indirect impacts of each alternative on park resources and values.

Table 4. Summary of alternatives for vaccination of free-ranging bison in Yellowstone National Park.

	ALTERNATIVE A (No Action)	**ALTERNATIVE B (Remote-Delivery Vaccination for Young Bison Only)**	**ALTERNATIVE C (Remote-Delivery Vaccination for Young Bison and Adult Females)**
Vaccinate young of both sexes	X	X	X
Vaccinate adult females	–	–	X
IBMP vaccine requirement	Safe (low risk)	Safe (low risk)	Safe (low risk)
Stephens Creek facility used for vaccination	X	X	X
Alternative includes remote delivery method	–	X	X
Vaccinate during spring	X	X	X
Vaccinate during autumn	–	X	X

Table 5. Comparison of alternatives and objectives.

Objectives	Alternatives		
	A - No Action	B – Remote-delivery vaccination for young bison	C – Remote-delivery vaccination for young bison and adult females
Preserve the migration of bison across the park boundary onto essential winter ranges in Montana	This alternative would allow the migration of bison across the park boundary onto winter ranges in Montana. The capture, handling, and holding of bison would likely have some unintended effects on bison behavior, but not significantly affect their migration patterns. The NPS does not have jurisdiction over bison in Montana and, as a result, there is uncertainty regarding management actions and the extent of tolerance.	This alternative would allow the migration of bison across the park boundary onto winter ranges in Montana. Capture effects are similar to Alternative A. Remote vaccination (i.e., without capture) of young bison in the park interior could have potentially negative behavioral impacts, with unknown effects on their use of certain areas and migration patterns. There is uncertainty regarding management and the extent of tolerance for bison in Montana.	This alternative would allow the migration of bison across the park boundary onto winter ranges in Montana. Capture effects are similar to Alternative A. Remote vaccination of young bison and adult females in the park interior could potentially have more negative behavioral impacts than Alternative B, though effects on use areas and migration are unknown. There is uncertainty regarding management actions and the extent of tolerance for bison in Montana.
Decrease the probability of individual bison shedding *Brucella abortus* bacteria.	This alternative could decrease the probability of vaccinated bison shedding *Brucella abortus* in the short term if it was implemented consistently. However, this action is focused on young bison and is unlikely to induce a long-term protective immune response, which most experts agree is not attainable using a single dose of 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 protective immunity would remain. The probability of vaccinated bison shedding *Brucella abortus* may decrease over the short term. Given the current state of vaccine encapsulation and delivery technology, however, park-wide remote vaccination would likely have low efficacy at substantially decreasing brucellosis transmission.	The largest proportion of the Yellowstone bison population would be vaccinated and the probability of vaccinated bison shedding *Brucella abortus* may decrease over the long term. However, the uncertainty about the duration of protective immunity would remain and remote vaccination could have low efficacy at substantially decreasing brucellosis transmission. Almost certainly, remote vaccination would need to continue in perpetuity.

Table 5 (continued). Comparison of alternatives and objectives.

Objectives	Alternatives		
	A - No Action	**B – Remote-delivery vaccination for young bison**	**C – Remote-delivery vaccination for young bison and adult females**
Lower the brucellosis infection rate of 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 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 could be moderate after 30 years of implementation. This result is contingent on consistent vaccine hydrogel formulation and encapsulation, and delivery of consistent doses of vaccine to a large portion of the young bison in the population annually.	The model used to describe the environmental consequences to bison suggests that vaccination of adults could lead to a more rapid decrease in brucellosis 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. This result is contingent on consistent vaccine hydrogel formulation and encapsulation, and delivery of consistent doses of vaccine to a large portion of bison in the population annually.
Reduce the risk of brucellosis transmission to cattle outside the park	The risk of brucellosis transmission from bison to cattle is already quite low because management maintains separation between them. The anticipated reduction in shedding and infection due to hand-syringe vaccination and selective culling would continue to lower this risk. No actions would be taken to reduce brucellosis transmission by elk to cattle.	If successful over the long term, the anticipated moderate reduction in shedding and infection should lower transmission risk more than Alternative A. There are many uncertainties regarding the successful implementation of remote vaccination and its potential unintended effects on bison behavior. Also, no actions would be taken to reduce transmission by elk to cattle.	If successful over the long term, the anticipated moderate to major reduction in shedding and infection should lower transmission risk more than alternatives A and B. There are many uncertainties regarding the successful implementation of remote vaccination and its potential unintended effects on bison behavior. Also, no actions would be taken to reduce transmission by elk to cattle.
Develop, test, and use a safe and effective system to deliver vaccine to bison	Under this alternative, only hand-syringe vaccination of eligible bison at boundary capture facilities would be conducted. No remote vaccination would be attempted. However, research could be conducted to develop better vaccines, delivery methods, and diagnostics for reducing the prevalence of brucellosis.	Under this alternative, hand-syringe vaccination of bison at boundary capture facilities would continue and remote vaccination of young bison would be implemented using an air-powered rifle delivering a biobullet with vaccine payload. Research would be conducted to improve vaccines, delivery methods, and diagnostics.	Under this alternative, hand-syringe vaccination of bison at boundary capture facilities would continue and remote vaccination of young bison and adult females would be implemented using an air-powered rifle delivering a biobullet with vaccine payload. Research would be conducted to improve vaccines, delivery methods, and diagnostics.

Table 6. Comparison of environmental impacts by alternative.

IMPACT TOPICS	A - No Action	Alternative B – Remote-delivery vaccination for young bison	Alternative C – Remote-delivery vaccination for young bison and adult females
Bison Population			
Adaptive management (research/monitoring)	**Negligible to minor adverse impacts** could occur in the short term due to removing some bison from the wild for research in captivity, and capturing other bison in the wild to monitor vital rates (pregnancy, survival), responses to vaccination, and/or other factors. **Minor beneficial impacts** could occur over the long term if new information from monitoring and research leads to advances in brucellosis suppression, a reduction in intensive management actions, and/or greater tolerance for wild bison in Montana.	**Negligible to minor adverse and beneficial impacts** from this alternative are similar to those disclosed for Alternative A.	**Negligible to minor adverse and beneficial impacts** from this alternative are similar to those disclosed for Alternative A.
Injuries	**Minor adverse impacts** could result in the short term from injuries, infection, and stress sustained by bison during capture, confinement, physical restraint, and hand-syringe vaccination. Injured individuals could be more susceptible to predation and winter-kill following their release from captivity.	**Minor adverse impacts** from this alternative include those disclosed for Alternative A. In addition, the remote vaccination of young bison via biobullet could result in more tissue damage and a higher risk of bleeding and infection.	**Minor adverse impacts** from this alternative include those disclosed for alternatives A and B. There could be more injuries from remote vaccination because adult females would be vaccinated via biobullet in addition to young bison.

IMPACT TOPICS	A - No Action	Alternative B – Remote-delivery vaccination for young bison	Alternative C – Remote-delivery vaccination for young bison and adult females
Proportion of vaccinated bison	**Minor adverse impacts** could result in the short term from injuries, infection, and stress described above. **Minor beneficial impacts** could result from vaccinating a relatively small portion (1%) of the population. Vaccinated young and non-pregnant bison may have some resistance against future brucellosis transmission.	**Minor adverse impacts** could result in the short term from injuries, infection, and stress described above. **Minor to moderate beneficial impacts** could result in the long term from vaccinating a larger portion (10%) of the population due to remote vaccination of young bison. However, bison will likely react (e.g., changes in behavior) to remote delivery, which could reduce the portion vaccinated over time. Also, limitations of current remote delivery technologies (inconsistent vaccine hydrogel formulation; short rifle range) will reduce effectiveness.	**Minor adverse impacts** could result in the short term from injuries, infection, and stress described above. **Moderate beneficial impacts** could result in the long term from vaccinating a larger portion (29%) of the population due to remote vaccination of young and adult female bison. However, changes in bison behavior and the limitations of current remote-delivery technologies will likely reduce the portion of bison vaccinated over time.
Duration of protective immune response	**Minor beneficial impacts** could result from vaccinating young and non-pregnant bison and providing them with some short-term resistance against future brucellosis transmission. A single dose of SRB51 vaccine is not expected to provide lifetime resistance to *Brucella* bacteria.	**Minor beneficial impacts** from this alternative include those disclosed for Alternative A. With remote vaccination, there is a higher probability that bison vaccinated as calves would receive a second vaccination as yearlings. This booster vaccination could extend the duration of protective immune response, but probably not provide lifetime resistance to *Brucella*.	**Moderate to major beneficial impacts** could result from vaccinating young and adult female bison. With remote vaccination, there is a higher probability that many bison will receive multiple vaccinations through their lives; thereby extending the duration of the vaccine-induced protective immune response. However, the effects of bison nutrition, condition, and pregnancy/lactation could substantially lessen these protective immune responses.
Reduction in brucellosis prevalence	**Minor to moderate beneficial impacts** could result in the short and long term if brucellosis prevalence in the population is reduced by about 25% due to a lower probability of transmission following vaccination.	**Moderate beneficial impacts** could result in the short and long term if prevalence in the population is reduced by about 40% due to a lower probability of transmission following vaccination. However, it is highly uncertain whether substantial brucellosis reduction can be achieved given (1) our limited understanding of bison immune	**Major beneficial impacts** could result in the short and long term if prevalence in the population is reduced by about 66% due to a lower probability of transmission following vaccination. However, it is highly uncertain whether substantial brucellosis reduction can be achieved for the reasons outlined under

IMPACT TOPICS	A - No Action	Alternative B – Remote-delivery vaccination for young bison	Alternative C – Remote-delivery vaccination for young bison and adult females
		responses to suppression actions such as vaccination, (2) the absence of an easily distributed and highly effective vaccine, and (3) limitations of current diagnostic and vaccine delivery technologies.	Alternative B.
Protection from brucellosis-induced abortions	**Minor beneficial impacts** could result if vaccinating young and non-pregnant bison provides them with some short-term resistance against future brucellosis transmission. Hand-syringe vaccination with SRB51 provides only modest immune protection against *Brucella abortus*, including a 50-60% reduction in abortions, 45-55% reduction in infection of uterine or mammary tissues, and a 10-15% reduction in infection at parturition. However, only a small portion of the population is likely to be vaccinated under this alternative.	**Moderate beneficial impacts** could result if vaccinating and booster vaccinating young and non-pregnant bison provides them with longer resistance against future brucellosis transmission. Remote delivery of vaccine would likely induce less of a protective immune response than hand-syringe vaccination (described for Alternative A). Also, less than 10% of the population is likely to be vaccinated under this alternative.	**Major beneficial impacts** could result if vaccinating and booster vaccinating young and adult female bison provides them with long-term resistance against future brucellosis transmission. Remote delivery of vaccine would likely induce less of a protective immune response than hand-syringe vaccination. Also, less than 30% of the population is likely to be vaccinated under this alternative.
Risk of brucellosis transmission	**Minor beneficial impacts** could result in the short term due to a 50-60% reduction in future abortions (i.e., transmission events) by vaccinated animals. However, only a small portion of the population is likely to be vaccinated under this alternative. **Minor adverse impacts** could result in the short term from brucellosis-free bison being exposed to abortions by infectious bison in the capture facilities.	**Moderate beneficial impacts** could result in the short term due to a reduction in future abortions by more vaccinated animals. However, less than 10% of the population is likely to be vaccinated under this alternative. **Minor adverse impacts** may result for the reasons outlined under Alternative A.	**Moderate to major impacts** could result in the long term due to a reduction in future abortions by vaccinated young and adult female bison. About 30% of the population may be vaccinated under this alternative. **Minor adverse impacts** may result for the reasons outlined under Alternative A.
Behavior and demography	**Minor to moderate adverse impacts** could result in the short and long term because confinement and feeding may lead to food conditioning, disease transmission, and disruption of traditional migratory patterns. **Minor beneficial impacts** could result due to a reduction in future abortions by vaccinated animals, and possibly, a slight increase in calving rates and population growth.	**Moderate adverse impacts** could result in the short and long term because confinement and feeding may lead to food conditioning, disease transmission, and disruption of traditional migratory patterns. Also, remote vaccination could alter bison behavior in a way that leads to avoidance of people, disruption of social bonds, and higher energy expenditures by some individuals responding and avoiding the vaccine delivery teams.	**Moderate to major adverse impacts** could result in the short and long term because confinement and feeding may lead to food conditioning, disease transmission, and disruption of migratory patterns. Also, remote vaccination with increased time working around groups due to the added focus on adult females could alter bison behavior in a way that leads to avoidance of people, disruption of

IMPACT TOPICS	A - No Action	Alternative B – Remote-delivery vaccination for young bison	Alternative C – Remote-delivery vaccination for young bison and adult females
		Minor to moderate beneficial impacts could result due to a reduction in future abortions by vaccinated young and adult female bison, and an increase in calving rates and population growth.	social bonds, and higher energy expenditures. **Moderate to major beneficial impacts** could result due to a reduction in abortions by vaccinated bison, and an increase in calving rates and population growth.
Cumulative	**Negligible to major adverse impacts** could result from (1) the capture, confinement, and feeding of bison in Montana, (2) unintended harvest effects on bison demography and behavior, (3) livestock operations reducing tolerance for bison in some areas, (4) housing development fragmenting habitat or contributing to aggregations of bison that increase disease transmission and concentrate herbivory, (5) unintended effects of road grooming and winter recreation in Yellowstone that alter bison energy expenditures and behavior, (6) road and facility construction that disturb bison and their habitats, and (7) vehicle strikes and behavioral disturbances by visitors. **Negligible to major beneficial impacts** could result from (1) the capture and vaccination of bison by the State of Montana that reduces brucellosis transmission risk, (2) increased tolerance for bison in Montana due to hunting and an administrative rule change that eliminated many economic barriers created by the brucellosis class system, (3) quarantine efforts that provide a source of live, brucellosis-free bison for relocation elsewhere, (4) grooming of roads in Yellowstone for winter recreation that save bison energy while traveling and provide better access to foraging habitats, and (5) visitors gaining an appreciation of bison that could result in enhanced support for their	**Negligible to major adverse and beneficial impacts** from this alternative are similar to those disclosed for Alternative A.	**Negligible to major adverse and beneficial impacts** from this alternative are similar to those disclosed for Alternative A.

IMPACT TOPICS	A - No Action	Alternative B – Remote-delivery vaccination for young bison	Alternative C – Remote-delivery vaccination for young bison and adult females
	conservation as wildlife.		
Other Wildlife			
	Negligible to minor beneficial impacts could occur in the short and long term because fewer bison would be transmission vectors of brucellosis to other animals. **Negligible to minor adverse impacts** could occur in the short and long term from disturbance and displacement of wildlife near the capture and vaccination operations.	**Minor to moderate adverse and beneficial impacts** from this alternative include those disclosed for Alternative A. However, the impacts would be more widespread due to the implementation of park-wide remote vaccination. Also, some animals could be exposed to biobullets with vaccine that deflect from the intended bison target and fall to the ground and are eaten.	**Minor to moderate adverse and beneficial impacts** from this alternative include those disclosed for alternatives A and B.
Threatened/Endangered Species			
	Negligible to minor beneficial impacts could occur to grizzly bears, lynx, and wolverines in the short and long term because fewer bison would be transmission vectors of brucellosis to these species. **Negligible adverse impacts** to grizzly bears, lynx, critical habitat for lynx, and wolverines are expected due to grizzly bears denning during most bison capture operations, and spatial separation between capture facilities and lynx and wolverine use areas. If these threatened species fed on a carcass of a vaccinated bison, it would be less of a source of brucellosis infection that carcasses infected with field strains of *Brucella*.	**Negligible to minor adverse and beneficial impacts** from this alternative include those disclosed for Alternative A. However, the impacts would be more widespread due to the implementation of park-wide remote vaccination. Remote vaccination activities would not occur in areas where bears are observed.	**Negligible to minor adverse and beneficial impacts** from this alternative include those disclosed for alternatives A and B.
Ethnographic Resources			
	Minor to moderate adverse impacts could result in the short and long term because capture and vaccination operations are offensive to some American Indians and some tribes in general. Also, bison should not be consumed for 21 days after vaccination. Thus, vaccinated bison are held in the capture facility and not allowed to migrate into Montana where treaty harvests occur. **Minor to moderate beneficial**	**Moderate adverse and beneficial impacts** from this alternative include those disclosed for Alternative A. However, the impacts could be more extensive and widespread due to the implementation of park-wide remote vaccination.	**Moderate adverse and beneficial impacts** from this alternative include those disclosed for alternatives A and B.

IMPACT TOPICS	A - No Action	Alternative B – Remote-delivery vaccination for young bison	Alternative C – Remote-delivery vaccination for young bison and adult females
	impacts could result if vaccination contributes to decreasing brucellosis prevalence, which in turn, could increase bison productivity and contribute to more brucellosis-free bison for harvest and transfer to tribal lands.		
Health and Human Safety			
	Minor to moderate adverse impacts could result in the short and long term if humans (1) are accidentally exposed to the vaccine and/or become sick or injured during handling of vaccine and/or bison, or (2) consume meat that has vaccine residue in it. **Minor to moderate beneficial impacts** could occur if vaccination reduces the number of infected bison, and consequently, the exposure risk to humans most likely to encounter the bacteria (hunters, wildlife biologists, and veterinarians).	**Minor to moderate adverse and beneficial impacts** from this alternative include those disclosed for Alternative A. However, the impacts could be more extensive and widespread due to the implementation of park-wide remote vaccination. Also, it is uncertain how many hunters would be exposed to remotely vaccinated bison since these animals would not be held in captivity during the vaccine withdrawal time (when their meat should not be eaten).	**Minor to moderate adverse and beneficial impacts** from this alternative include those disclosed for alternatives A and B.
Visitor Use and Experience			
	Negligible to minor adverse impacts could result in the short term because visitors would not have access to about 800 hectares of the Gardiner basin. Also, some visitors would be annoyed about the handling, confinement, and vaccination of bison. **Negligible to minor beneficial impacts** could result because some individuals would appreciate attempts to reduce brucellosis prevalence in bison and the risk of transmission to cattle.	**Minor to major adverse and beneficial impacts** from this alternative include those disclosed for Alternative A. However, the impacts could be more extensive and widespread due to the use of park-wide remote vaccination. Remote vaccination would result in additional injuries, the marking of more bison, and more than likely, changes in bison behavior (avoidance of people) that reduce visitor viewing opportunities. Impacts could be beneficial for visitors that support the protection of Montana's cattle industry and maintaining its brucellosis class-free status.	**Minor to major adverse and beneficial impacts** from this alternative include those disclosed for alternatives A and B.
Park Operations			
	Negligible to minor adverse impacts could result in the short and long term from maintenance needs to keep the capture	**Minor to moderate adverse and beneficial impacts** from this alternative include those disclosed for Alternative A.	**Moderate to major adverse and beneficial impacts** from this alternative include those disclosed for

IMPACT TOPICS	A - No Action	Alternative B – Remote-delivery vaccination for young bison	Alternative C – Remote-delivery vaccination for young bison and adult females
	facility in good repair, staffing needs to support the hazing, capture, vaccination, and monitoring of bison, and staff time and effort to respond to requests from other agencies, media, tribes, and stakeholder groups or individuals. **Negligible to minor beneficial impacts** could result from providing new information that increases understanding of the implications and effects of managing and vaccinating bison, which could be used to address social conflicts related to bison.	However, the impacts would be more extensive and widespread due to the use of park-wide remote vaccination. Some park staff would be required to learn and implement new skills and technologies. Also, there could be occasional traffic delays due to remote vaccination. In addition, there would be additional levels of inquiry, increased reporting requirements, and additional duties by some park staff related to vaccine encapsulation.	alternatives A and B.

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). The portion of the GYE specifically subject to analysis includes approximately 89,030 hectares 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 (2,040 meters 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. The Yellowstone River flows through a wide valley northwest of Gardiner, Montana and is generally less than 1,675 meters in elevation (Barmore 2003).

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 (Geremia et al. 2011). Thermal areas in Yellowstone National Park 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 sent to slaughter during winter

2005-2006, and more than 1,400 bison were consigned to slaughter during winter 2007-2008 (White et al. 2011). Meat and hides from these bison were distributed to American Indian tribes and civic charitable food banks. The count in summer 2013 was approximately 4,600 bison.

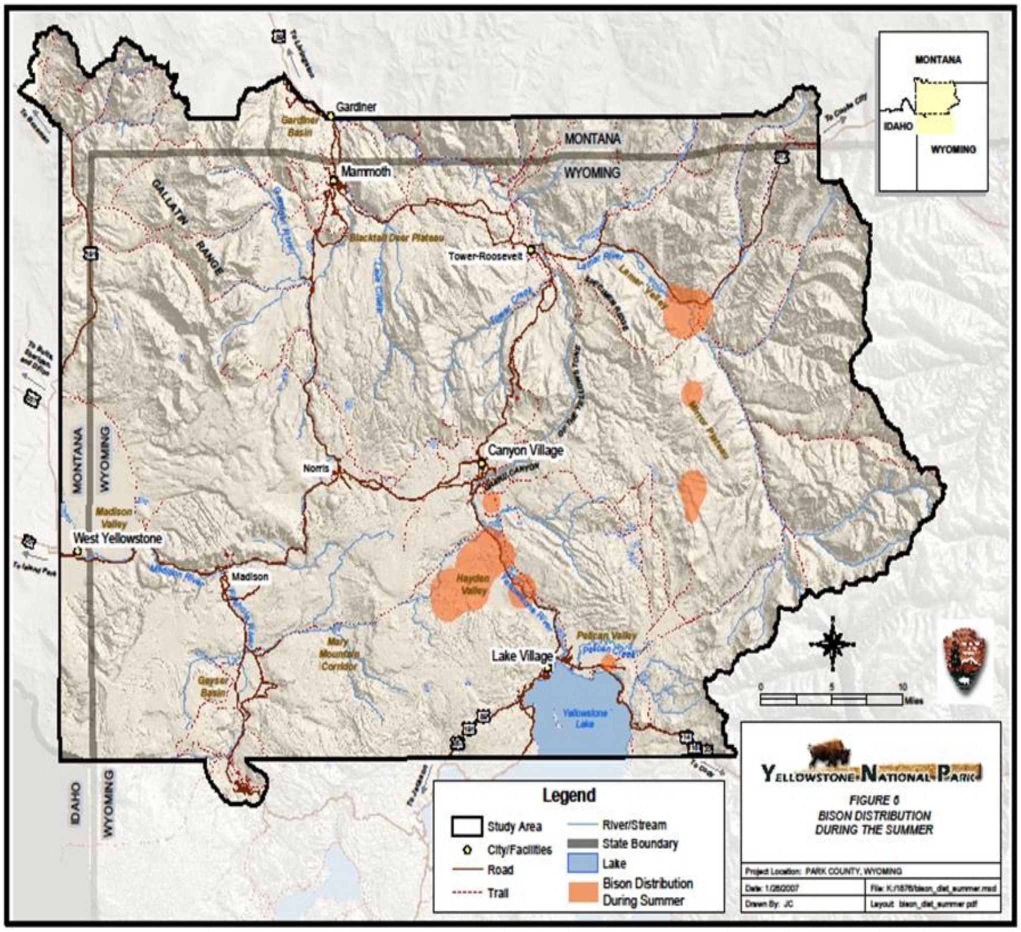

Figure 5. Yellowstone bison distribution during summer.

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 at least six geographically separated locations that contain narrow corridors for movement between winter range areas (Table 7, 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.

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).

Table 7. 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

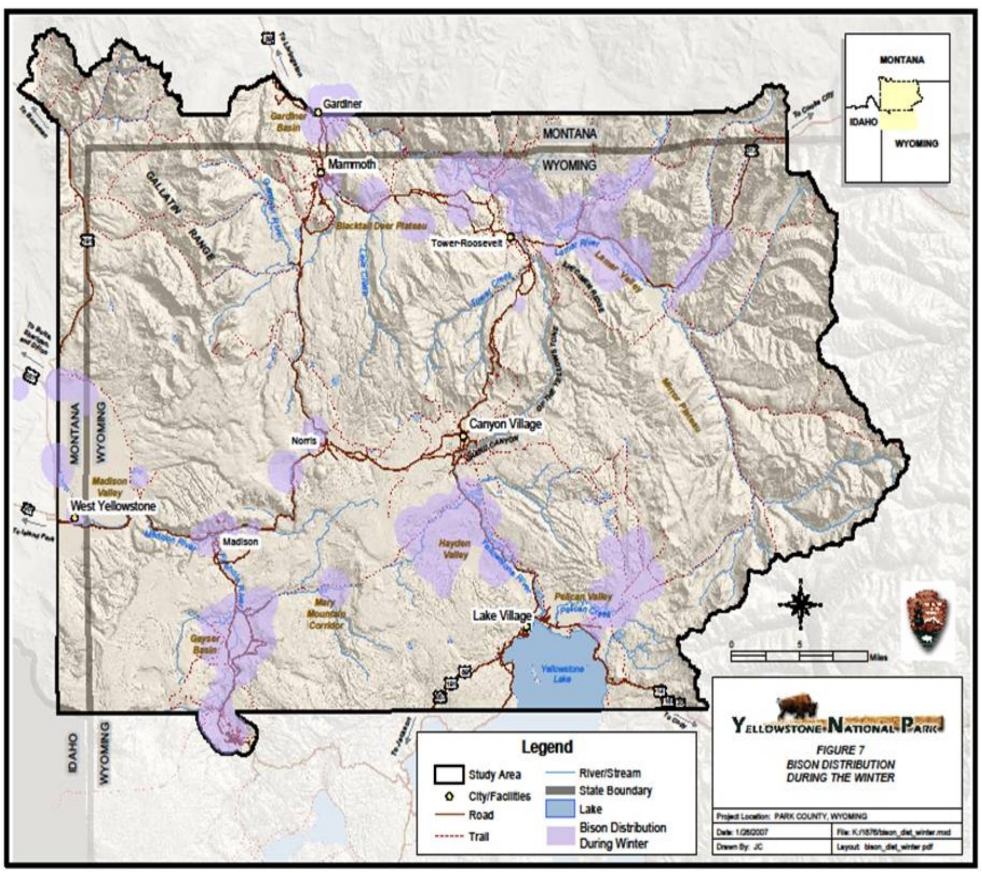

Figure 6. Yellowstone bison distribution during winter.

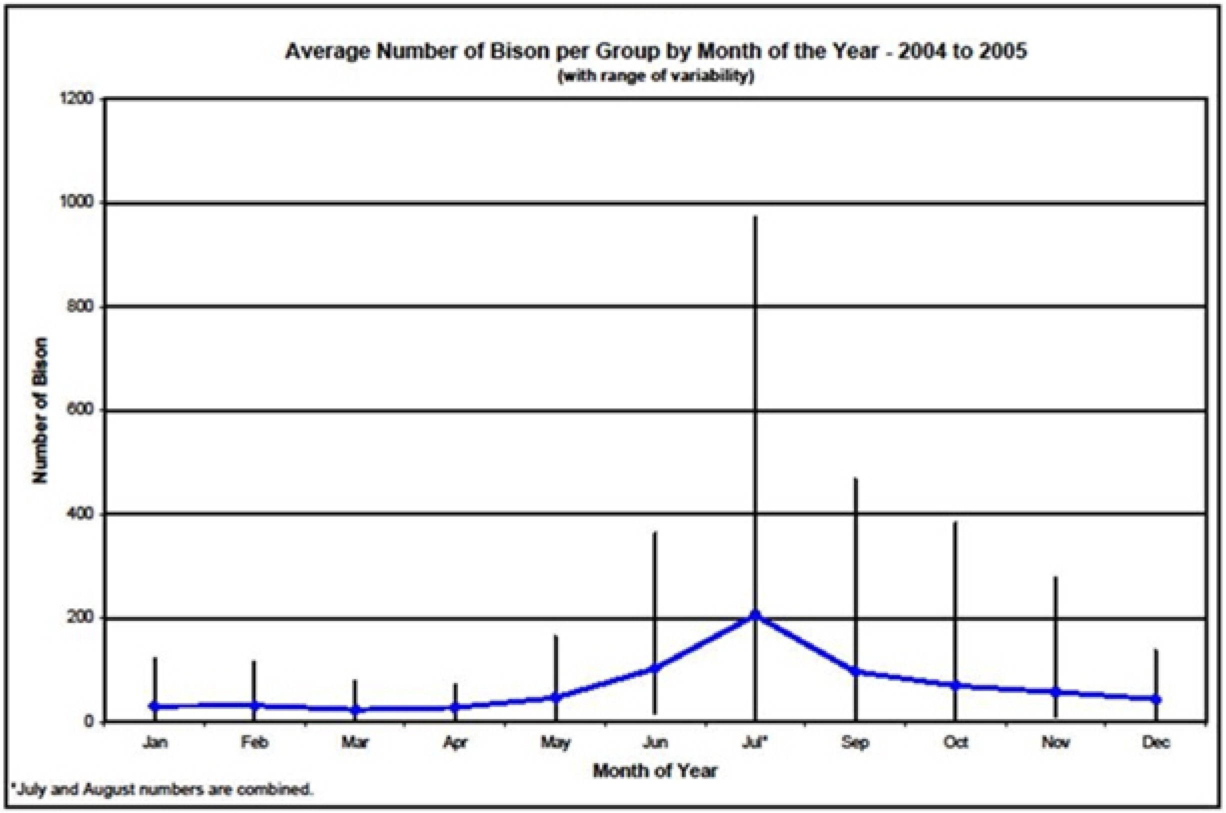

Figure 7. Average number of bison per group by month of year.

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 similarly 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 *Brucella abortus*, with 40-60% of Yellowstone bison testing positive for exposure to *Brucella abortus* during 1985 to 2012 (Cheville et al. 1998, Hobbs et al. 2013). 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 populations (Gooseberry, Cody, Clarks Fork, Ruby Valley) appear to have increased to more than 7-12% since about 2002. This increase is possibly due to elk-to-elk brucellosis 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. 2010). The costs of management actions to substantially reduce brucellosis prevalence in wild bison and elk are high. For example, the Wyoming Game and Fish Department spent about $1.3 million during a 5-year effort to capture 2,624 elk, test 1,286 female elk, and cull 197 seropositive animals (Scurlock et al. 2010, Schumaker et al. 2012).

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, 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 *Brucella 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. (2012) observed similar results in experiments conducted in the northern GYE. Predation and scavenging by carnivores likely decontaminates the local environment of infectious *Brucella 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 *Brucella 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.

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, 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 during 2008 and livestock producers incurred increased testing costs and marketing complications to verify that livestock were brucellosis-free. The USDA reinstated Montana's brucellosis class-free status in 2009. Regardless of these regulatory changes, Montana's gross annual income from cattle sales surpassed $1 billion five times in the past seven years; primarily due to beef sales to foreign countries with strong economic growth (Lutey 2012). Cattle prices have been at record highs since 2010 and show little signs of decreasing (Lutey 2012).

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 cattle would increase with increasing bison numbers and severe snow depths or thawing and freezing events that caused bison to occupy more areas outside Yellowstone National Park where cattle graze. 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, 10 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 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 weather, geology, elevation, and vegetation diversity.

Large carnivores in the park include coyotes, black bears (*Ursus americanus*), grizzly bears, mountain lions (*Puma concolor*), and wolves. 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 focus on bison calves in some areas during winter (Jaffe 2001, Smith et al. 2000, Becker et al. 2009a,b).

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 (*Pica hudsonia*), and many other species of smaller perching birds along with coyotes, red foxes, badgers, and numerous carnivorous insects are likely to scavenge on bison carcasses.

3.6 Threatened, Endangered, 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 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 FWS 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).

Canada Lynx

The lynx (*Lynx canadensis*) 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 (*Lepus americanus*), the lynx's principal prey (USDI, FWS 2000). 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 (USDI, FWS 2000). Critical habitat for lynx was designated in Yellowstone National Park and surrounding lands in southwestern Montana and northwestern Wyoming (Unit 5; USDI, FWS 2009).

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 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 (USDI, FWS 2000).

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 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.

Gray Wolf

Gray wolves were eliminated by humans from the northern Rocky Mountains by the 1930s. In 1978, the FWS published a rule (USDI, FWS 1978a) listing them as an endangered species throughout the conterminous 48 States and Mexico (except for Minnesota where the gray wolf was reclassified to threatened). In November 1994, the FWS 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 (USDI, FWS 1994). This designation enabled the reintroduction of 41 wolves from southwestern Canada into Yellowstone National Park during 1995 through 1997 (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 (FWS et al. 2003).

The northern Rocky Mountain population of the gray wolf was designated a distinct population segment and removed from the List of Endangered and Threatened Wildlife in 2011 (USDI, FWS 2011a). At the end of 2012, at least 83 wolves in 10 packs occupied Yellowstone National Park. 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 et al. 2011). Maintaining wolf populations above recovery levels in the GYE segment of the northern

Rocky Mountains area will depend on some wolf packs living outside Yellowstone National Park and surrounding wilderness areas (USDI, FWS 2006a, 2007a, 2008b).

During autumn and winter in 2012-2013, the states of Idaho, Montana, and Wyoming implemented hunting and/or trapping seasons for wolves, including in areas adjacent to Yellowstone National Park. Twelve wolves, or about 12% of the total number of wolves that primarily lived in Yellowstone, were legally harvested when they moved outside the park. This level of human-caused mortality is not expected to substantially influence wolf numbers in the park over the long term. To ensure that wolf numbers around the park remain healthy, however, park staff met with staff from Montana and Wyoming to discuss harvest strategies in hunting districts along the boundary of the park.

Wolves in Yellowstone primarily feed on elk, with bison comprising only a minor portion of kills even though counts of elk spending winter in or near the park have decreased about 80% since 1995 when wolves were initially reintroduced (Becker et al. 2009a,b; Metz et al. 2012, White et al. 2012a). Bison are larger than elk and employ group defenses that make them more difficult to kill (Smith et al. 2000, Becker et al. 2009a). However, predation has become a larger factor for bison since wolf and grizzly bear recovery (Smith et al. 2004, Becker et al. 2009a,b). Wolves tend to kill more bison during winters with deep and prolonged snow pack that make malnourished animals more numerous and vulnerable (Becker et al. 2009a). Wolves also kill more bison as bison numbers increase relative to elk and there are more bison calves in the population (Becker et al. 2009a,b). The effects of wolf predation on bison population growth are still relatively minor—though this could change in the future (Geremia et al. 2009).

Grizzly Bear

Grizzly bears were listed as a threatened species in the lower 48 states during 1975 (USDI, FWS 2005) because the GYE population had been reduced to between 229 and 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 differs in that bears consume terrestrial mammals as their primary source of nutrition (Mattson 1997, Miller and Waits 2003; USDI, FWS 2005). Intensive management has resulted in this population increasing at a rate of 4 to 7% per year since the early 1990s and more than 600 bears now persist in the GYE (Schwartz et al. 2006). The range and distribution of grizzly bears have expanded since 2000 and 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). There are sufficient numbers and distribution of reproductive individuals to provide a high likelihood that grizzly bears will continue to exist and be well distributed throughout their range for the foreseeable future (USDI, FWS 2005).

As a result, the FWS 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 in April 2007 (USDI, FWS 2007b). 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 (USDI, FWS 2005). 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 (USDI, FWS 2005). In September 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. The government challenged this decision before the 9th U.S. Circuit Court of Appeals, but the decision was upheld, in part, during November 2011 and the threatened status for grizzly bears in the greater Yellowstone ecosystem was sustained (Case 09-36100, Greater Yellowstone Coalition versus Wyoming).

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 (USDI, FWS 1978b). 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 FWS reclassified the bald eagle from endangered to threatened in 1995 for the 43 contiguous states (USDI, FWS 1999a). Populations of bald eagles continued to increase and data indicate the bald eagle has recovered in the lower 48 states, with an estimated minimum of 7,066 breeding pairs in 2010 compared to 487 active nests in 1963 (USDI, FWS 2010).

Numbers of nesting and fledgling bald eagles in Yellowstone National Park also increased incrementally during 1987-2011 (Smith et al. 2012). 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 and there have been 31-34 nest attempts per year since 2001. The park may have reached saturation in the number of nesting pairs that can be supported (Smith et al. 2012). The FWS removed the bald eagle from the List of Endangered and Threatened Wildlife in August 2007 (USDI, FWS 2007c). The bald eagle is currently designated as delisted-recovered, with a recovery plan calling for monitoring of their status every 5 years from 2008 to 2028.

American Peregrine Falcon

The American peregrine falcon (*Falco peregrinus anatum*) was removed from the List of Endangered and Threatened Wildlife and Plants in August 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 (USDI, FWS 1999b). The FWS has implemented a post-delisting monitoring plan 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 (USDI, FWS 2006b).

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 32 pairs and 47 fledglings by 2007 (Smith et al. 2012). During 2011, park staff confirmed nesting at 12 of 20 occupied sites, 11 of which fledged at least one young (92% success) for a total of 21 young (Smith et al. 2012).

Wolverine
The FWS proposed to list the wolverine as a threatened species under the Endangered Species Act in February 2013, while finding that critical habitat was not determinable at that time (USDI, FWS 2013). The southern portion of the species' range extends into portions of Idaho, Montana, and Wyoming. The wolverine is a wide-ranging mustelid (weasel family) that naturally exists at low densities ranging from one animal per 65 to 337 square kilometers (Hornocker and Hash 1981, Banci 1994). Wolverines are highly adapted to extreme cold and life in environments that have snow on the ground for much of the year (Aubry et al. 2007). Persistent snow cover from at least mid-winter through mid-May is necessary to maintain the warmth and security of offspring in dens during late winter and spring, as well as to avoid high summer temperatures above their physiological tolerance (Magoun and Copeland 1998, Aubry et al. 2007, Copeland et al. 2010). Persistent snow cover generally occurs at mountainous elevations above 2,440 meters in the contiguous United States (Copeland et al. 2007).

Wolverines travel long distances and are opportunistic feeders that primarily scavenge on carrion (Hornocker and Hash 1981). They are sensitive to human disturbance from February to May when young are born and cannot travel far (Magoun and Copeland 1998). Overexploitation through hunting and trapping, as well as predator poisoning, likely caused wolverine abundance and distribution to decrease since the early 1900s along the southern portion of their historical range (Banci 1994). However, recent surveys indicate they are widely distributed in remote mountain regions of Idaho, Montana, and parts of Wyoming (USDI, FWS 2003). Current threats to wolverines include climate warming, human disturbance (e.g., recreational activities), and development (e.g., transportation corridors; USDI, FWS 2013).

Wolverines are rare and sparsely distributed in Yellowstone National Park and adjacent national forest areas (Beauvais and Johnson 2004, Inman et al. 2007, Murphy et al. 2011). During 2005 to 2009, wolverines were captured or detected in the Absaroka-Beartooth wilderness along the north boundary of the park, the Thorofare region (southeast corner), and the adjoining Washakie and Teton wilderness areas (Murphy et al. 2011). No wolverines were captured or detected inside the park in the Gallatin Range (northwest), the Central Plateau and Washburn Range (central), the Madison Plateau and Bechler region (southwest), and the Snake River Range (south). Also, no wolverines were detected in the North Absaroka wilderness and adjoining areas along the east boundary of the park, including the upper Lamar River (Murphy et al. 2011). Radio-marked wolverines selected mountainous habitats above 2,450 meters with persistent snow cover and adequate ungulates during winter to provide carrion for food (Murphy et al. 2011). Home ranges in the GYE averaged 797 square kilometers for adult males and 329 square kilometers for adult females (Inman et al. 2007). In Yellowstone National Park, home ranges of radio-marked wolverines did not overlap, reproductive rates appeared low, and survival rates were similar to estimates for other populations in the conterminous United States (Murphy et al. 2011). Dispersal from other populations in the GYE may be necessary to maintain wolverines in the park, given the low recruitment of offspring born to resident females (Murphy et al. 2011).

Whitebark Pine
Whitebark pine (*Pinus albicaulis*) is a 5-needled conifer species with a life-span of up to 500 years. It occurs at elevations over 2,440 meters and periodically produces abundant crops of high quality seeds that are consumed by more than 20 species of vertebrates, including grizzly bears (Felicetti et al. 2003). Whitebark pine is threatened by the mountain pine beetle, white

pine blister rust, and climate warming (Logan et al. 2010, Tomback and Achuff 2010). The mountain pine beetle is a native beetle that periodically causes widespread mortality of pine trees, including whitebark pine. Since the early 2000s, the mountain pine beetle has caused substantial tree mortality in the GYE (Logan et al. 2010). However, high levels of mountain pine beetle mortality are not unprecedented. Large-scale epidemic outbreaks of mountain pine beetle also occurred in the Yellowstone ecosystem in the 1930s and 1970s (Despain 1990).

White pine blister rust is an exotic fungus that arrived in North America in the late 1920s. Since its arrival it has killed many whitebark pine trees in the Pacific Northwest and northern Rocky Mountains, including Glacier National Park (Tomback et al. 2001). White pine blister rust has been less lethal in the GYE than other areas, but does continue to spread. Surveys suggest that approximately 25% of the whitebark pine trees in the GYE are infected with rust, but rust-caused mortality of infected trees is less than 6%, much lower than other ecosystems (Greater Yellowstone Whitebark Pine Monitoring Working Group 2011). Recent climate warming trends may also contribute to the decrease in whitebark pine through competition from species such as lodgepole pine that are more successful on warmer sites (Logan et al. 2010). A warmer climate may also aid the spread of mountain pine beetle and blister rust by producing more favorable conditions for them. These threats will likely reduce the numbers and distribution of whitebark pine in the Yellowstone ecosystem (Logan et al. 2010, Tomback and Achuff 2010).

In July 2011, the FWS concluded that whitebark pine warranted being added to the Lists of Endangered and Threatened Wildlife and Plants, but such listing was precluded by higher priority actions. Instead, whitebark pine was added to the candidate species list (USDI, FWS 2011b).

Pronghorn

Pronghorn in Yellowstone National Park were identified as a Native Species of Special Concern by park managers 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 concerns about the viability of Yellowstone pronghorn because low abundance (fewer than 400) and apparent isolation until recently increased their susceptibility to random, naturally occurring catastrophes (National Research Council 2002). During the 1900s, the Yellowstone pronghorn migration was effectively truncated by up to 80 kilometers outside the park due to development and habitat fragmentation (Caslick 1998, Scott 2004). Also, several summering areas were apparently abandoned after culls and translocations during the 1940s through the 1960s (Scott and Geisser 1996, Keating 2002). In April 2013, 351 pronghorn were counted on their winter range in the Gardiner basin of Yellowstone National Park and nearby areas of Montana. The population exhibits irruptive dynamics with periods of relative stability for 10 to 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).

Along with these challenges, Yellowstone pronghorn share a 30-square kilometer 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 through 1990 (Singer and Norland 1994, Singer and Renkin 1995). Since 2000, however, genetic and telemetry data suggest there has been dispersal from the Yellowstone population to the southern Paradise Valley in Montana, north of the park (K. Barnowe-Meyer, University of Idaho, unpublished data). The persistence of this recently-formed population (about 105 pronghorn in 2013), with dispersal and gene flow between the two populations, would improve the long-term viability of the Yellowstone population.

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. Today there are approximately 30,000 trumpeter swans in North America (USDI, FWS 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 9 individuals in 2011 (Baril et al. 2011, Smith et al. 2012). There was some evidence that this decrease in abundance became more dramatic after supplemental feeding of swans outside the park (Centennial Valley, Montana) was terminated in the winter of 1992-1993 (Proffitt et al. 2009*a*). There was little evidence that numbers of migrants affected the abundance of the resident population, but growth 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, 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*). There was no swan reproduction in Yellowstone National Park during 2011 (Smith et al. 2012). 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. Trumpeter swan presence may be limited to ephemeral residents and wintering aggregations of migrants from outside the park (Proffitt et al. 2009*a*,*b*).

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). Pelican numbers have increased in recent years, 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). In 2010, a total of 87 young were fledged from 427 nest attempts, suggesting the population had recovered somewhat from the substantial decrease during the mid- to late-1990s (Baril et al. 2011). However, all of the 684 nests observed on the Molly Islands during 2011 were submerged by nearly record setting water levels in Yellowstone Lake (Smith et al. 2012).

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 (USDI, NPS 2010c). 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 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 (USDI, NPS 2010c).

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 populations. Archeological evidence places the earliest human occupation in Yellowstone National Park at 11,000 years ago, though many tribes believe that they have been on the landscape for time immemorial (Nabokov and Loendorf 2004). No fewer than 10 tribes dwelled in the GYE during both historic and prehistoric times and 26 tribes claim some level of association with the GYE. Tribes whose traditional territory included portions of the Yellowstone Plateau include the Crow, Eastern Shoshone, Salish and Kootenai, Shoshone-Bannock, Blackfeet (footnote 4, Table 8), Nez Perce, Northern Arapaho, and Northern Cheyenne (Nabokov and Loendorf 2004). The GYE also contained important hunting grounds for many tribes. As late as the l880s, a band of Shoshone known as the Sheepeaters occupied portions of what is now Yellowstone National Park (Nabokov and Loendorf 2004). A few tribes currently claim hunting rights within Yellowstone National Park, including the Nez Perce and 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 (Nabokov and Loendorf 2004).

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 (Nabokov and Loendorf 2004). 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 (Nabokov and Loendorf 2004). Seventeen years later, the 1868 Fort Laramie Treaty removed many hectares of GYE land from tribal control, but allowed hunting in unoccupied lands. Shoshone and Bannock treaties did not include reference to the Yellowstone area, but they did reference hunting on unoccupied lands as well (Nabokov and Loendorf 2004).

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 from 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 (Plumb and Sucec 2006). 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 (USDI, NPS 2010a). Many contemporary tribes maintain a spiritual connection with bison. Consumptive use of land and its resources, and decimation of the bison populations, helped to alter the interrelated world of both tribes and bison.

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 8). Twenty of these 26 groups are current members of the InterTribal Buffalo Council, which was organized in 1990 to restore 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 vaccine delivery.
- Potential for transmission of brucellosis to humans.
- Distribution of live bison testing negative for brucellosis exposure to tribes. The FEIS for the IBMP indicated the IBMP agencies supported the distribution of live bison that 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- and long-term issues about bison management needs, the first six are most closely related to the bison vaccination program and this EIS.

Table 8. 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
Northern Cheyenne tribe	yes	Southeast Wyoming, Northeast Colorado, Northwest Kansas, Southwest Nebraska	Bison

Tribe	ITBC1	Historic Area	Associations
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 Buffalo Council (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 56 current member tribes of the ITBC listed on their web site. 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 undulant fever (brucellosis in humans) in Wyoming or Idaho attributed to wildlife (Greater Yellowstone Interagency Brucellosis Committee 1997). In Montana, there were two confirmed cases of hunters contracting undulant fever from elk, with the last 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.

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 approximately 3.4 million visitors in 2012. 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.

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 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 about 223 hotel rooms and cabins and 85 campsites in the NPS-managed campground available for visitors, while the Tower-Roosevelt area has about 80 cabins and a 32-site campground (out of a total of about 2,238 motel rooms and cabins and 2,211 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 240 kilometers 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. 2000a). 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).

Bison summer and winter ranges are generally located in valleys 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 kilometers 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. Thus, 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 visits in the winter of 1994-1995 (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 Deputy Superintendent. The staff is organized into several operating divisions, including Administration, Concessions Management, Human Resources/Procurement, Maintenance, Resource and Visitor Protection, Resource Education and Youth Programs, and the Yellowstone 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. Other funding comes from competitive grants and donations through the Yellowstone Park Foundation.

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 in Yellowstone National Park. Also, the NPS employs more than 500 people in the park, requiring a significant administrative branch to manage the logistics of finance, purchasing, information transfer, and technical communications. Park staff maintains about 710 buildings, while concessionaires maintain about another 830 park-owned structures. The infrastructure connecting to these developments includes water and sewage systems, about 750 kilometers of roadway, and approximately 1,600 kilometers 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.

Current bison vaccination operations are based out of the Stephens Creek corral and holding paddocks northwest of Gardiner, Montana. 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.

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 A.

4.1 Evaluation of Impact Topics

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 intensity of impact definitions and an analysis of the impacts of each alternative, followed by an assessment of cumulative impacts. Possible mitigation measures are identified.

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, though this time-period may be reduced if monitoring is focused on 2- to 3-year-old bison (Ebinger and Cross 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).

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 (beneficial or adverse, direct or indirect), context (local or regional), duration (short- or long-term, seasonal or continuous), and intensity (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. 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.

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 management actions including hazing and capture and lethal removal of bison.
- Construction projects within the park, including building renovation and reconstruction and reconstruction of bridges and roads.
- Winter recreation in the park and changing restrictions on winter visitor use.
- 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.
- Vegetation restoration - The USFS and NPS are attempting to restore native plants to some areas of the Gardiner and Hebgen basins 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.

4.2 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, as described in the IBMP. The transmission of brucellosis from bison to cattle requires that infected, pregnant bison shed *Brucella 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 *Brucella 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 levels of intensity used to describe the impacts of the proposed actions are as follows:

- *Negligible*—There would be no observable or measurable impacts to bison, their habitats, or the natural processes sustaining them. Impacts would be well within natural fluctuations. Changes in brucellosis prevalence would be slight to undetectable.
- *Minor*—Impacts on bison, their habitats, or the natural processes sustaining them would be detectable, but would not be outside the natural range of variability. Small changes to population numbers, population structure, genetic variability, and other demographic factors might occur. Occasional responses to disturbance by some individuals could be expected, but without interference to feeding, movements, reproduction, or other factors affecting population-level parameters. Impacts would be outside critical reproduction periods. Brucellosis prevalence could change by 10% from estimated baseline levels.
- *Moderate*—Impacts on bison, 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 populations would remain viable. Frequent responses to disturbance by some individuals could be expected, with some negative impacts to feeding, movements, reproduction, or other factors affecting population-level parameters. Some impacts might occur during critical periods of reproduction. Brucellosis prevalence could change by 50% from estimated baseline levels.
- *Major*—Impacts on bison, 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 changes. Frequent responses to disturbance by many individuals would be expected, with substantial negative impacts to feeding, movements, reproduction, or other factors affecting population-level parameters. Brucellosis prevalence could change by greater than 50% from 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.

A stochastic, individual based model 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. 2007, 2010). 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 G).

The model provided information on the relationship of two responses that are difficult to monitor (number of infectious events and vaccine-protected bison) and two that can be monitored (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 and subsequently shipped to slaughter. 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 (Treanor et al. 2007, 2010). Model projections of these four results were used as criteria for quantifying the relative impacts of the three alternatives.

It is important to reiterate that this model was developed to enable direct comparisons of differences among vaccination alternatives, and necessarily was based on assumptions that reduced model complexity. Assumptions included: 1) remote delivery of vaccine to free-ranging bison would provide protection equal to bison given syringe vaccinations when handled at the boundary; 2) there would be an increase in immune protection with booster vaccination; 3) all bison captured at the park boundary were tested and positive reactors (i.e., bison with antibodies indicating previous exposure to brucellosis) were removed; 4) all bison testing negative for brucellosis exposure that migrated to the boundary were vaccinated and remained protected against infection when exposed to the field strain at specified probabilities corresponding to possible vaccine efficacy; and 5) no abortions or mortality occurred due to vaccination itself (Treanor et al. 2010). Furthermore, the model was not intended to make accurate, precise estimates of brucellosis suppression amounts and timelines due to uncertainty in parameters used to inform the model (e.g., weather, abundance of bison, and shifts in behavior in response to management actions). When uncertainty is included, predictive models generally show large variation in expected outcomes, with far less confidence in achieving desired conditions (Hobbs et al. 2013).

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

Research

Adaptive management adjustments regarding the vaccination of bison at boundary capture facilities could include changes in vaccine, change in the number and type of animals vaccinated, or discontinuing vaccination. The consideration of alternate vaccines or delivery of vaccine to additional animals (e.g., pregnant females in late gestation) would necessitate additional studies in controlled environments and the field to assess the level and duration of protective immune response and potential for abortions and shedding of *Brucella* bacteria following vaccination. Similar types of studies were generally described in the original monitoring plan for Yellowstone bison (White et al. 2008; also see Appendix E). Some captive studies may require removing about 100 bison (2% of 4,600 bison) from the Yellowstone population. Negligible to minor adverse impacts could occur from these studies in the short term due to removing some bison from the wild for research in captivity, and capturing other bison in the wild to monitor vital rates (pregnancy, survival), responses to vaccination, and/or other factors. However, the population is reproductively prolific and can recover rapidly from relatively small decreases in abundance (USDI, FWS 2007d; White et al. 2011). Minor beneficial impacts could occur over the long term if new information from monitoring and research leads to advances in brucellosis suppression, a reduction in intensive management actions, and/or greater tolerance for wild bison in Montana.

<u>Injuries</u>

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 bison. 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.

Calf and yearling bison captured at the pens may be hand-injected with brucellosis vaccine. A common side effect from hand-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 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.

Minor adverse impacts could result in the short term from injuries, infection, and stress sustained by bison during capture, confinement, physical restraint, and hand-syringe vaccination at Stephens Creek. Injured individuals could be more susceptible to predation and winter-kill following their release from captivity.

<u>**Proportion of Vaccinated Bison**</u>

Implementation of Alternative A would result in vaccinating a small proportion of the bison population (calves and yearlings that move to the park boundary; Figure 9). Some bison make 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). Access to bison for hand-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. Therefore, minor adverse impacts could result in the short term from injuries, infection, and stress described above. Minor beneficial impacts could result from vaccinating a relatively small portion (1%) of the population. Vaccinated young and non-pregnant bison may have some resistance against future brucellosis transmission.

<u>Duration of Protective Immune Response</u>

Vaccine SRB51 is considered low risk for reproductively immature bison (Olsen et al. 1997, 1998; Davis and Elzer 2002). However, the duration of the protective immune response induced by SRB51 is uncertain and a single dose of SRB51 given to calves and yearlings is not expected to provide lifetime resistance to *Brucella*. Since this alternative targets only a small proportion of young bison, these individuals would not receive additional (booster) vaccinations aimed at extending the duration of the protective immune response. The ability of *Brucella abortus* to persist in bison 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 *Brucella abortus* when calving. Therefore, minor beneficial impacts could result from vaccinating young and non-pregnant bison and providing them with some short-term resistance against future brucellosis transmission.

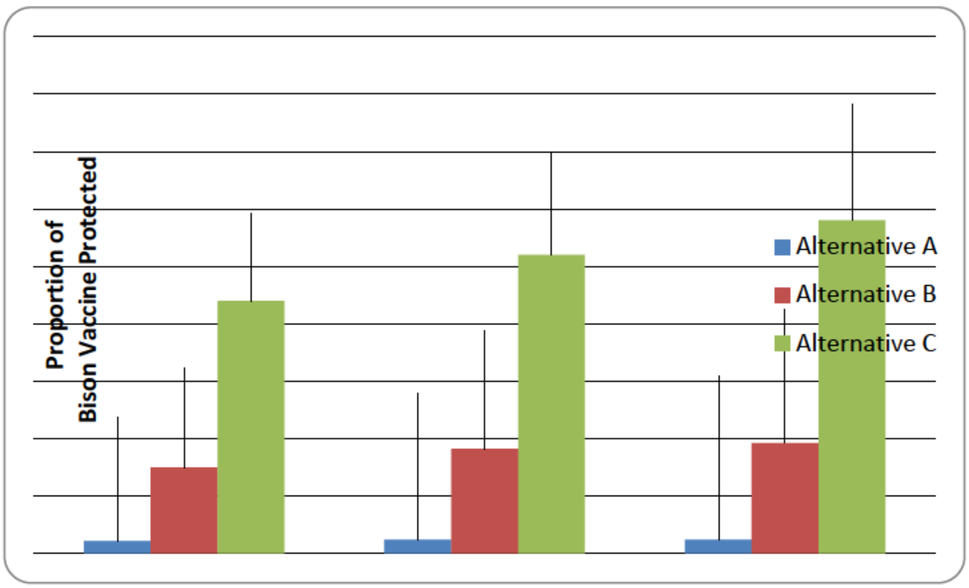

Figure 8. Model comparisons of the proportion of vaccine-protected bison for the three vaccination alternatives based on an intermediate (50%) level of vaccine efficacy. Error bars indicate the standard deviation of the average value (variation in individual model runs relative to the average values presented in the bar plots).

<u>Reduction in Brucellosis Prevalence</u>

Because of the low number of young bison vaccinated annually, model simulations estimated a moderate reduction in brucellosis seroprevalence in the population from the initial state of about 47% to about 35% (about a 25% decrease [(1 – 35/47)*100]) over a 30-year period (Figure 10, Table 9). 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 (Treanor et al. 2010). Therefore, minor to moderate beneficial impacts could result in the short and long term if brucellosis prevalence in the population is reduced by about 25% due to a lower probability of transmission following vaccination.

Protection from Brucellosis-induced Abortions

The focus of vaccination under this alternative is to develop protective immune responses in reproductively immature bison to lessen the probability of them aborting their first pregnancy should they become exposed to field strain *Brucella abortus*. However, the level of reduction in brucellosis prevalence from the implementation of this alternative offers only a small degree of protection from *Brucella*-induced abortions at the population level and, as a result, moderate levels of infectious events are expected to occur within the population over the 30-year simulation period (Treanor et al. 2010). Minor beneficial impacts could result if vaccinating young and non-pregnant bison provides them with some short-term resistance against future brucellosis transmission. Hand-syringe vaccination with SRB51 provides only modest immune protection against *Brucella abortus*, including a 50-60% reduction in abortions, 45-55% reduction in infection of uterine or mammary tissues, and a 10-15% reduction in infection at parturition. Also, only a small portion of the population is likely to be vaccinated under this alternative.

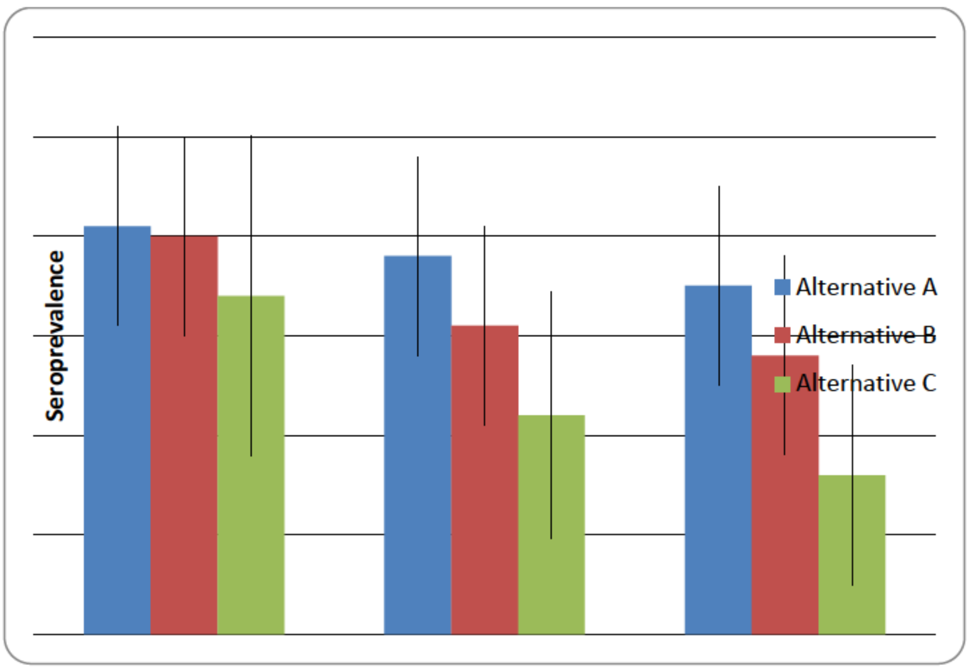

Figure 9. Model comparisons of brucellosis seroprevalence decreases for the three vaccination alternatives at 10-, 20-, and 30-year intervals. Error bars indicate the standard deviation of the average value (variation in individual model runs relative to the average values presented in the bar plots).

Risk of Brucellosis Transmission

The relatively few bison vaccinated at capture facilities near the park boundary under this alternative would have little impact on reducing infection and the amount of *Brucella abortus* shed on the landscape. Also, capturing and holding bison in captivity to implement hand-syringe vaccination can actually increase the risk of brucellosis transmission to other bison if an abortion or infectious live birth occurs. Thus, minor beneficial impacts could result in the short term due to a 50-60% reduction in future abortions (i.e., transmission events) by vaccinated animals. However, only a small portion of the population is likely to be vaccinated under this alternative. Minor adverse impacts could result in the short term from brucellosis-free bison being exposed to abortions by infectious bison in the capture facilities.

Behavior and Demography

Under this alternative bison could be captured at the Stephens Creek facility in Yellowstone National Park to test and remove animals infected with brucellosis and vaccinate young animals. Vaccinated bison should not be consumed within 21 days of delivery because it takes this length of time for the vaccine to clear an animal's system. Therefore, vaccinated bison are held within the capture facility for at least this length of time if hunting of bison in Montana is ongoing. These bison are subsequently released, but confinement and feeding with hay obviously conflicts with the management of bison as wildlife and could have unintended consequences such as food-conditioning, disease transmission during confinement, and disruption of traditional migratory patterns (White et al. 2013).

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). Model simulations suggest a small reduction in population seroprevalence and vaccine protection against *Brucella abortus*-induced abortions under Alternative A (Figure 10), which would likely have a correspondingly small influence on increasing bison calving rates and population growth. As a result, the small proportion of the population vaccinated and potentially re-vaccinated under Alternative A will have little effect on bison population growth.

Minor to moderate adverse impacts result in the short and long term because confinement and feeding may lead to food conditioning, disease transmission, and disruption of traditional migratory patterns. Minor beneficial impacts could result due to a reduction in future abortions by vaccinated animals, and possibly, a slight increase in calving rates and population growth.

Table 9. 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

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, livestock operations, housing development, quarantine efforts, winter recreation, road and facility construction, and increased visitation.

Capture facilities.—The State of Montana could operate capture facilities outside the park to manage the risk of brucellosis transmission to cattle. Bison outside the park may be captured and tested for brucellosis exposure, and calves and yearlings that test negative could be vaccinated and released. This operation would likely be run similar to the program conducted at

Stephens Creek by the NPS and potential impacts would be similar to those described previously for Alternative A inside the park. Both federal and state vaccination operations are directed by the IBMP and could benefit bison by directly reducing brucellosis infection and indirectly reducing transmission risk from bison to cattle. However, the state has rarely used their capture facilities since 2000 with less than 10 bison vaccinated.

Hunting.—Hunting in Yellowstone National Park is not authorized by Congress and longstanding policy prohibits hunting in units of the NPS system unless specifically authorized by Congress (NPS Organic Act of 1916, 16 USC I, V § 26). However, hunting outside the park is used to manage the abundance and distribution of bison on the landscape, while providing sporting and subsistence food gathering opportunities. In 2005, Montana Fish, Wildlife & 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 & 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. In 2006, Montana recognized rights reserved by treaties with the United States government for the Confederated Salish and Kootenai tribes of the Flathead Nation and the Nez Perce Tribe to harvest bison on some federal lands in southwestern Montana. In 2009 and 2010, Montana also recognized the treaty rights of the Shoshone-Bannock tribes and the Confederated tribes of the Umatilla Indian Reservation, respectively, to harvest bison on these lands.

The Montana bison hunt and tribal treaty harvest have been successfully implemented with variable harvest levels each year depending on how many bison move outside the park in response to snow depth conditions in the higher mountains. Starting in 2007, Montana Fish, Wildlife & Parks set a state quota of 44 either-sex permits with up to 100 additional cow-calf permits if more than 60 bison were in a hunting district. The permits are allocated between two hunting districts in the Gardiner and West Yellowstone areas. The American Indian tribes direct their own harvests, but managers from the tribes and Montana Fish, Wildlife & Parks coordinate each summer regarding bison permits and harvests, and to ensure fair chase hunts, avoid killing every bison that migrates out of the park, and to preserve respect for the bison as a game animal and as a valuable part of tribal heritage and culture. The tribes and Montana Fish, Wildlife & Parks enforce regulation and permit requirements for their respective hunters by sending enforcement officers to oversee hunts. Total harvest approximated 250 bison in 2013 and demographic modeling suggests that the removal of 200-400 females per year could maintain relatively stable population abundance (Hobbs et al. 2013).

Livestock operations.—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 constrains the expansion of the conservation area for wild bison. However, changes in the federal and state regulatory processes for livestock diseases have been implemented in the GYE that have lessened the economic costs of cattle occasionally being re-infected with brucellosis by wildlife. The Animal and Plant Health Inspection Service implemented an interim rule in 2010 (U.S. Department of Agriculture, Animal and Plant Health Inspection Service 2010) that allows detections (or outbreaks) of brucellosis in domestic livestock to be dealt with on a case-by-case (or herd-by-herd) basis. The interim rule removes the provision for automatic reclassification of any Class Free State or area to a lower status if two or more herds are found to have brucellosis within a 2-year period or if a single brucellosis-affected herd is not depopulated within 60 days. As long as outbreaks are investigated and contained by removing all cattle testing positive for exposure, then corrective regulations are not imposed on the rest of the cattle producers in the state. In fact, brucellosis was detected in several domestic bison and cattle herds in Idaho, Montana, and Wyoming during 2009 and 2010, without any state-wide corrective actions being implemented. The interim rule eliminates many economic barriers created by the brucellosis class status system and should increase tolerance for bison and the potential for expansion of the conservation area for wild bison near Yellowstone National Park. Also, the ranching tradition in southwestern Montana has conserved large tracts of land that are often used by wildlife, but could otherwise be developed for housing tracts or other uses not compatible with wildlife.

Housing development.—Land use is expanding and intensifying on unprotected lands in the GYE, primarily from growth in the number of rural homes (Gude et al. 2007). This development has fragmented valley bottom habitats with higher plant productivity and more moderate winter conditions that are crucial for the migration and seasonal use by bison, elk, pronghorn, and other wildlife in this mountainous environment (Hansen and DeFries 2007). Development can also contribute to human-induced refuges from predation or human harvest that contribute to ungulates aggregating in large groups that increase the potential for disease transmission and concentrate herbivory (Haggerty and Travis 2006).

Quarantine efforts.—The IBMP discussed the use of quarantine to provide flexibility in handling seronegative bison and in providing a source of live, brucellosis-free bison for tribal governments and requesting organizations (USDI and USDA 2000a,b). During 2005 through 2008, Montana Fish, Wildlife & Parks and the USDA, Animal and Plant Health Inspection Service (2006) initiated a quarantine feasibility study with bison calves from Yellowstone National Park that initially tested negative for brucellosis exposure. All of these bison were held at a research facility north of Yellowstone National Park to evaluate if they would remain free of brucellosis through at least their first pregnancy and calving. By 2010, the quarantine feasibility study was deemed successful and the surviving original bison and their offspring were considered brucellosis-free by the State of Montana and the Animal and Plant Health Inspection Service (Montana Fish, Wildlife & Parks 2010, 2011). In February 2010, 87 bison were transferred from the quarantine facility to the Green Ranch in Montana owned by Turner Enterprises, Inc. for five years of additional surveillance. Thereafter, the original quarantine bison plus about 25% of their offspring will be transferred to American Indian tribes or public lands as directed by Montana Fish, Wildlife & Parks (Montana Fish, Wildlife & Parks 2010). The rest of the bison will be retained by Turner Enterprises. In March 2012, Montana transferred 61 bison from the quarantine facility to the Fort Peck Indian Reservation for five years of additional surveillance (Montana Fish, Wildlife & Parks 2011). In August 2013, the Fort Peck Assiniboine and Sioux tribes transferred 34 of these bison (or their offspring) to the Fort Belknap Reservation in Montana.

The ROD for the IBMP indicated that "additional NEPA analysis on features of the quarantine process and facility is anticipated in the future" if the agencies determined quarantine was "a necessary or desirable component of the bison management program"—thereby "offering another public input opportunity" at that time (USDI and USDA 2000b:42, 61). Thus, the NPS may work with other IBMP members to (1) evaluate alternates for the general location(s) of one or more quarantine facilities, (2) establish protocols and responsibilities for implementing operational quarantine, (3) evaluate whether to proceed with implementing operational quarantine with Yellowstone bison, and if so, (4) evaluate the scale (e.g., number of bison and quarantine facilities) at which operational quarantine should be conducted. Per the IBMP, the NPS will continue to consult with tribes in communications and meetings regarding the progress of these evaluations and seek their input. There would likely be negligible to minor adverse impacts to the bison population from removing small numbers of bison for quarantine. Beneficial impacts of quarantine could cumulatively become moderate to major in scope depending on how long quarantine operations provided brucellosis-free bison for relocation to new areas. The beneficial impacts are due to creating a source of live bison to assist in the conservation of the species and to reduce the social conflict over killing Yellowstone bison that are not infected with brucellosis.

Winter recreation.—The impacts of road grooming (packing snow-covered roads to facilitate over-snow vehicle recreation) on bison distribution and movements in Yellowstone National Park have been intensely debated since the 1970s. Meagher (1993, 1998) reported increased numbers of bison, coupled with increases in distribution, during 1983-1995 and proposed that road grooming enabled these changes. While the coincidental occurrence of road grooming and range expansion by bison does not equate to cause and effect, groomed roads could have contributed to these changes by saving bison energy while traveling and providing better access to foraging habitat; thereby resulting in enhanced population growth and increased movements to the park boundary (Meagher 1993, 1998; Taper et al. 2000, Coughenour 2005). As a result, Meagher (2003) recommended eliminated road grooming to reduce the number and rate of bison leaving the park and induce them to revert to their traditional (pre-road grooming) distributions.

Other scientists have concluded that the 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 and Broberg 2011). Road grooming did not change the population growth rates of bison relative to what may have been realized in without road grooming (Gates et al. 2005, Bruggeman et al. 2006, Fuller 2006, Wagner 2006). As a result, 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). Bison do not preferentially use groomed roads (Bruggeman et al. 2009a), and 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. 2006, 2007, 2009a,b). Thus, bison use of travel corridors that include these road segments would likely persist whether or not roads were groomed (Gates et al. 2005, Bruggeman 2006). Furthermore, 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. 2009a).

After considering these concerns and findings, the NPS developed a Supplemental EIS, ROD, and long-term regulation during 2013 that will continue the grooming of interior park roads for over-snow vehicles (USDI, NPS 2013). During the winter of 2013-2014, a maximum of 318 best-available-technology, commercially guided snowmobiles will be allowed each day in Yellowstone National Park, along with up to 78 commercially guided snow coaches. During the following winter, however, the park would begin to manage oversnow vehicles based on their overall impacts to air quality, soundscapes, wildlife, and visitors, rather than focusing on the number of snowmobiles and snowcoaches allowed in the park each day (USDI, NPS 2013). The park would allow up to 110 "transportation events" a day, initially defined as either one snowcoach or on average a group of seven snowmobiles. No more than 50 transportation events a day would be allocated for groups of snowmobiles.

Road and facility construction.—Other previously described park-level actions include road and facility construction, which may also have cumulative impacts to bison such as increased behavioral responses during the construction phase. However, long-term impacts should not occur since new traffic corridors or facility sites would not be built.

Increased visitation.—Visitation to Yellowstone National Park has consistently increased since the 1990s and approximated 3.4 million visitors during 2012. Increased visitation and subsequent increases in traffic, wildlife observation, and photography result in some vehicle strikes and behavioral disturbances to bison. However, visitors also gain an appreciation of bison, which often results in enhanced support for their conservation as wildlife.

Conclusion

Under Alternative A, negligible to minor adverse impacts could occur in the short term due to (1) removing some bison from the wild for research in captivity, (2) capturing other bison in the wild to monitor vital rates (pregnancy, survival), responses to vaccination, and/or other factors, and (3) injuries, infection, and stress sustained by bison during capture, confinement, physical restraint, and hand-syringe vaccination. Minor to moderate adverse impacts could result in the short and long term because confinement and feeding may lead to food conditioning, disease transmission, and disruption of traditional migratory patterns.

Under Alternative A, minor beneficial impacts could occur over the long term (1) if new information from monitoring and research leads to advances in brucellosis suppression, a reduction in intensive management actions, and/or greater tolerance for wild bison in Montana, (2) vaccinating a relatively small portion (1%) of the population (young and non-pregnant bison) provides some short-term resistance against future brucellosis transmission and a 50-60% reduction in future abortions (i.e., transmission events) by vaccinated animals, and (3) if a slight increase in calving rates and population growth occurs. Minor to moderate beneficial impacts could result in the short and long term if brucellosis prevalence in the population is reduced by about 25% due to a lower probability of transmission following vaccination.

Negligible to major adverse cumulative impacts could result from (1) the capture, confinement, and feeding of bison in Montana, (2) unintended harvest effects on bison demography and behavior, (3) livestock operations reducing tolerance for bison in some areas, (4) housing development fragmenting habitat or contributing to aggregations of bison that increase disease transmission and concentrate herbivory, (5) unintended effects of road grooming and winter recreation in Yellowstone that alter bison energy expenditures and behavior, (6) road and facility construction that disturb bison and their habitats, and (7) vehicle strikes and behavioral disturbances by visitors.

Negligible to major beneficial cumulative impacts could result from (1) the capture and vaccination of bison by the State of Montana that reduces brucellosis transmission risk, (2) increased tolerance for bison in Montana due to hunting and an administrative rule change that eliminated many economic barriers created by the brucellosis class system, (3) quarantine efforts that provide a source of live, brucellosis-free bison for relocation elsewhere, (4) grooming of roads in Yellowstone for winter recreation that save bison energy while traveling and provide better access to foraging habitats, and (5) visitors gaining an appreciation of bison that could result in enhanced support for their conservation as wildlife.

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.

Research

Adaptive management adjustments that could occur generally fall into four categories, including changes in vaccine, delivery method, and the timing of delivery, or discontinuing remote delivery. The consideration of alternate vaccines or forms of vaccine delivery may necessitate additional studies in controlled environments and the field to assess the level and duration of protective immune response following vaccination. Deciding to discontinue remote delivery if a minimum level of vaccine delivery (such as more than 50% of eligibles vaccinated) cannot be maintained on an annual basis or there is no indication of progress through a decrease in seroprevalence and infection would return the bison population to the current situation (Alternative A) and associated impacts.

There are many research and monitoring activities that need to be conducted before implementing park-wide vaccination (Section 2.2). The development, testing, and production of a 2-stage (vaccine plus booster) biobullet using SRB51 vaccine (Grainger 2011) would not affect the Yellowstone bison population because this research and development would occur in a laboratory. Neither would work with scientists to develop a polymerase chain reaction assay or other methods for potentially detecting active infection of *Brucella abortus* in live bison since this effort would use stored blood and tissue samples or those collected from bison captured for other purposes (research, management). The refinement of models that describe brucellosis dynamics in Yellowstone bison and estimate the portion of eligible bison that must be vaccinated each year would not affect the Yellowstone bison population because this would involve computer simulations. Neither would queries to the State of Montana for commitments to (1) conduct vaccination of bison and cattle, (2) selectively cull likely infectious bison, (3) increase tolerance for bison on public lands in Montana, and (4) modify hunting seasons as necessary to consider a sufficient withdrawal time following vaccination because this would involve negotiations, not field efforts.

However, assessing the level and duration of protective immune response following remote-delivery vaccination (and booster vaccination) may require studies in controlled environments (quarantine, captive facilities) and the field. The basic design, objectives, and numbers of bison needed for these studies are generally described in the original monitoring plan for Yellowstone bison (White et al. 2008; also see Appendix E). Some captive studies may require removing about 100 bison from the Yellowstone population. We would also assess bison injuries and behavioral responses to remote-delivery vaccination during these studies in controlled environments and field studies.

Negligible to minor adverse impacts could occur in the short term from occasionally removing about 100 animals (2% of 4,600 bison) from the wild for research in captivity, and capturing other bison in the wild to monitor vital rates (pregnancy, survival), responses to vaccination, and/or other factors. However, the population is reproductively prolific and can recover rapidly from relatively small decreases in abundance (USDI, FWS 2007d; White et al. 2011). Moreover, recent modeling efforts suggest that during most winters the IBMP members may need to remove this many bison or more to progress towards population abundance guidelines described in the IBMP and subsequent adaptive management adjustments. Minor beneficial impacts could occur over the long term if new information from monitoring and research leads to advances in brucellosis suppression, a reduction in intensive management actions, and/or greater tolerance for wild bison in Montana.

Injuries

Remote-vaccine delivery causes a greater level of tissue damage and a higher probability of bleeding at the injection site than hand-syringe delivery due to differences in the diameter of the delivery tools and the 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 SRB51 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. 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. 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. It is possible that some proportion of the animals will succumb to injury due to a variety of uncontrollable features (such as the projectile severing a sensitive nerve embedded within the muscle mass of the target). Also, bison with biobullet related injuries may be at a higher risk of predation and aggressive interactions other bison.

Minor adverse impacts from this alternative include those disclosed for Alternative A. In addition, the remote vaccination of young bison via biobullet could result in more tissue damage and a higher risk of bleeding, infection, predation, and aggression or injuries inflicted by other bison.

Proportion of Vaccinated Bison

This alternative is expected result in minor adverse impacts in the short term from injuries, infection, and stress as described for Alternative A. Model simulations suggest the implementation of Alternative B would result in an increase in the number of vaccinated bison to about 10% over a 30-year period (Figure 9), which is about 10 times the level estimated for Alternative A. The additional increase in the number of bison vaccinated under Alternative B, combined with other efforts to reduce brucellosis prevalence, will increase beneficial impacts and could increase tolerance for untested bison outside of Yellowstone. Thus, minor to moderate beneficial impacts could result in the long term from vaccinating a larger portion (10%) of the population due to remote vaccination of young bison. However, bison will likely react (e.g., changes in behavior) to remote delivery, which could reduce the portion vaccinated over time. Also, limitations of current remote delivery technologies (inconsistent vaccine hydrogel formulation; short rifle range) will reduce effectiveness.

Duration of Protective Immune Response

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 the protective immune response. Alternative B does not provide an opportunity to vaccinate bison as adults and 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 the protective immune response will probably not last the remainder of an individual's life. No impacts from vaccine-induced abortions (i.e., transmission) are expected because the calves and yearlings are not reproducing and would not be pregnant when vaccinated. As a result, minor beneficial impacts are expected from the relatively short duration of vaccine-induced protective immune response. Booster vaccination as yearlings could extend the duration of protective immune response, but probably not provide lifetime resistance to *Brucella*.

Reduction in Brucellosis Prevalence

Alternative B combines the test, remove, and vaccinate strategy of Alternative A with remote vaccination. Model simulations estimated a decrease in seroprevalence from the initial state of about 47% to about 28% (a 40% decrease [(1 – 28/47)*100]) over a 30-year period, versus 35% for Alternative A (Figure 10). With less transmission occurring, fewer bison are expected to react positively to serologic tests and be shipped to slaughter. This would increase the management options available for decision makers. As a result, moderate beneficial impacts could result in the short and long term if prevalence in the population is reduced by about 40% due to a lower probability of transmission following vaccination. However, it is highly uncertain whether substantial brucellosis reduction can be achieved given (1) our limited understanding of bison immune responses to suppression actions such as vaccination, (2) the absence of an easily distributed and highly effective vaccine, and (3) limitations of current diagnostic and vaccine delivery technologies.

Protection from Brucellosis-induced Abortions

A higher proportion of vaccinated bison would lead to greater overall resistance in the population from transmitting brucellosis than Alternative A. The moderate decrease in brucellosis prevalence under this alternative is anticipated to result in a corresponding level of resistance against *Brucella*-induced abortions in the bison population. Therefore, moderate beneficial impacts could result if vaccinating and booster vaccinating young and non-pregnant bison provides them with longer resistance against future brucellosis transmission. However, remote delivery of vaccine would likely induce less of a protective immune response than hand-syringe vaccination (described for Alternative A). Also, less than 10% of the population is likely to be vaccinated under this alternative.

Risk of Brucellosis Transmission
A reduction of infectious birth material shed on the landscape under Alternative B should result from the greater number of bison vaccinated as compared to Alternative A (Figure 9). Since the focus of vaccination efforts would be on reproductively immature animals, there would be no short-term impacts resulting from vaccine-induced abortions and subsequent brucellosis transmission risk to susceptible individuals. More management options are available when there is a higher proportion of bison with vaccine-induced protective immune responses and fewer seropositive bison are removed during boundary management operations. Thus, moderate beneficial impacts could result in the short term due to a reduction in future abortions by more vaccinated animals. However, less than 10% of the population is likely to be vaccinated under this alternative. Minor adverse impacts could result in the short term from brucellosis-free bison being exposed to abortions by infectious bison in the capture facilities.

Behavior and Demography
Young bison 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 biologists are 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 a startle response on impact, kicking the leg injected by a 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 often react to dart delivery of immobilization chemicals in a similar way. However, some free-ranging bison on Catalina Island of the coast of southern California reacted to vaccination by a 2-inch, spring-loaded dart fired from an air rifle by biting at other nearby bison or charging the person firing the dart (Siegler 2013, Tata 2013).

Park staff conducted over 100 field immobilizations of bison and reactions to immobilizing darts were generally mild. Based on these observations, bison reactions to remote vaccination via biobullet 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. In other words, remote vaccination could alter bison behavior in a way that leads to aggression or the avoidance of people.

Bison calving rates could increase if vaccine-induce protective immune responses against *Brucella*-induced abortions are sustained until vaccinated bison reach reproductive age. In turn, improved calving rates could increase bison population growth (Fuller et al. 2007b). Also, 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 9). Consequently, Alternative B could result in fewer seropositive bison shipped to slaughter during boundary management operations than Alternative A.

Consequently, moderate adverse impacts could result in the short and long term because confinement and feeding may lead to food conditioning, disease transmission, and disruption of traditional migratory patterns. Also, remote vaccination could alter bison behavior in a way that leads to aggression, avoidance of people, disruption of social bonds, and higher energy expenditures by some individuals responding to and avoiding the vaccine delivery teams. Minor to moderate beneficial impacts could result due to a reduction in future abortions by vaccinated young and adult female bison, and an increase in calving rates and population growth.

<u>**Cumulative Impacts**</u>
Anticipated cumulative impacts would be similar to those described in Alternative A.

Conclusion
Under Alternative B, negligible to minor adverse impacts could occur in the short term due to (1) removing some bison from the wild for research in captivity, (2) capturing other bison in the wild to monitor vital rates (pregnancy, survival), responses to vaccination, and/or other factors, and (3) injuries, infection, and stress sustained by bison during capture, confinement, physical restraint, and hand-syringe vaccination. The remote vaccination of young bison via biobullet could result in more tissue damage and a higher risk of bleeding and infection than Alternative A. Minor to moderate adverse impacts could result in the short and long term because confinement and feeding may lead to food conditioning, disease transmission, and disruption of traditional migratory patterns. Also, remote vaccination could alter bison behavior in a way that leads to aggression, avoidance of people, disruption of social bonds, and higher energy expenditures by some individuals responding to and avoiding the vaccine delivery teams.

Under Alternative B, minor beneficial impacts could occur over the long term (1) if new information from monitoring and research leads to advances in brucellosis suppression, a reduction in intensive management actions, and/or greater tolerance for wild bison in Montana, (2) bison vaccinated as calves receive a second vaccination as yearlings, and (3) this booster vaccination extends the duration of protective immune response. Minor to moderate beneficial impacts could result in the long term (1) from vaccinating a larger portion (10%) of the population due to remote vaccination of young bison, (2) if brucellosis prevalence in the population is reduced by about 40% due to a lower probability of transmission following vaccination, (3) vaccinating and booster vaccinating young and non-pregnant bison reduces future abortions by more vaccinated animals, and (4) an increase in calving rates and population growth occurs. However, remote delivery of vaccine would likely induce less of a protective immune response than hand-syringe vaccination (described for Alternative A). Also, bison will likely react (e.g., changes in behavior) to remote delivery, which could reduce the portion vaccinated over time. In addition, the absence of an easily distributed and highly effective vaccine and limitations of current remote delivery technologies (inconsistent vaccine hydrogel formulation; short rifle range) will reduce effectiveness.

Negligible to major adverse cumulative impacts could result from (1) the capture, confinement, and feeding of bison in Montana, (2) unintended harvest effects on bison demography and behavior, (3) livestock operations reducing tolerance for bison in some areas, (4) housing development fragmenting habitat or contributing to aggregations of bison that increase disease transmission and concentrate herbivory, (5) unintended effects of road grooming and winter recreation in Yellowstone that alter bison energy expenditures and behavior, (6) road and facility construction that disturb bison and their habitats, and (7) vehicle strikes and behavioral disturbances by visitors.

Negligible to major beneficial cumulative impacts could result from (1) the capture and vaccination of bison by the State of Montana that reduces brucellosis transmission risk, (2) increased tolerance for bison in Montana due to hunting and an administrative rule change that eliminated many economic barriers created by the brucellosis class system, (3) quarantine efforts that provide a source of live, brucellosis-free bison for relocation elsewhere, (4) grooming of roads in Yellowstone for winter recreation that save bison energy while traveling and provide better access to foraging habitats, and (5) visitors gaining an appreciation of bison that could result in enhanced support for their conservation as wildlife.

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.

Research

Impacts of adaptive management adjustments and the research and monitoring activities that need to be conducted before implementing park-wide vaccination are described in Alternative B. Negligible to minor adverse impacts could occur in the short term from occasionally removing about 100 animals (2% of 4,600 bison) from the wild for research in captivity, and capturing other bison in the wild to monitor vital rates (pregnancy, survival), responses to vaccination, and/or other factors. However, the population is reproductively prolific and can recover rapidly from relatively small decreases in abundance (USDI, FWS 2007d; White et al. 2011). Moreover, recent modeling efforts suggest that during most winters the IBMP members may need to remove this many bison or more to progress towards population abundance guidelines described in the IBMP and subsequent adaptive management adjustments. Minor beneficial impacts could occur over the long term if new information from monitoring and research leads to advances in brucellosis suppression, a reduction in intensive management actions, and/or greater tolerance for wild bison in Montana.

Injuries

Minor adverse impacts from this alternative include those disclosed for alternatives A and B. There could be more injuries from remote vaccination because adult females would be vaccinated via biobullet in addition to young bison. 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 aggression from other bison.

Proportion of Vaccinated Bison

This alternative is expected result in minor adverse impacts in the short term from injuries, infection, and stress as described for Alternative A. Model simulations estimate the number of vaccinated bison in the population under Alternative C should increase to about 29% over a 30-year period (Figure 9), which is about three times the number of vaccinated bison under Alternative B. Thus, moderate beneficial impacts could result in the long term from vaccinating a larger portion (29%) of the population due to remote vaccination of young and adult female bison. However, changes in bison behavior and the limitations of current remote delivery technologies will likely reduce the portion of bison vaccinated over time.

Duration of Protective Immune Response

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 the vaccine-induced protective immune response. 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 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, moderate to major beneficial impacts could result from vaccinating young and adult female bison. With remote vaccination, there is a higher probability that many bison will receive multiple vaccinations through their lives; thereby extending the duration of the vaccine-induced protective immune response. However, the effects of bison nutrition, condition, and pregnancy and lactation could substantially lessen these protective immune responses.

Reduction in Brucellosis Prevalence

Over the 30-year simulation period, Alternative C was estimated to reduce seroprevalence substantially more than Alternative A and Alternative B (Figure 10). Model simulations of the impacts of Alternative C estimate a potential decrease in seroprevalence from about 47% to about 16% (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 9). Major beneficial impacts could result in the short and long term if prevalence in the population is reduced by about 66% due to a lower probability of transmission following vaccination. However, it is highly uncertain whether substantial brucellosis reduction can be achieved given (1) our limited understanding of bison immune responses to suppression actions such as vaccination, (2) the absence of an easily distributed and highly effective vaccine, and (3) limitations of diagnostic and vaccine delivery technologies.

Protection from Brucellosis-induced Abortions

Long-term protective immune responses from repeatedly vaccinating a greater proportion of female bison could lead to higher levels of immunity (resistance) to *Brucella*-induced abortions in the population (Figure 9). Therefore, major beneficial impacts could result if vaccinating and booster vaccinating young and adult female bison provides them with long-term resistance against future brucellosis transmission. However, remote delivery of vaccine would likely induce less of a protective immune response than hand-syringe vaccination (described for Alternative A). Also, less than 30% of the population is likely to be vaccinated under this alternative.

Risk of Brucellosis Transmission
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 *Brucella 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 *Brucella abortus* shed onto the landscape in a given year is the sum of these infectious events. The decrease in infectious events should be greater for Alternative C than for either Alternative A or Alternative B. Because Alternative C would maximize the number of bison that are vaccine-protected, it should result 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 higher proportion of bison that would be vaccinated (Figure 9). As a result, moderate to major impacts could result in the long term due to a reduction in future abortions by vaccinated young and adult female bison. About 30% of the population may be vaccinated under this alternative. Minor adverse impacts could result in the short term from brucellosis-free bison being exposed to abortions by infectious bison in the capture facilities.

Behavior and Demography
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 before they move away from field delivery crews. However, having two distinct vaccination periods could somewhat reduce the need to vaccinate a high percentage of each group during a single episode. Adult Yellowstone bison have shown mild initial reactions to being struck with immobilizing darts and similar reactions to remote-vaccine delivery are expected. However, the level of tolerance bison will have for continued remote vaccination is uncertain, and bison could alter their behavior in a way that could lead to aggression or the avoidance of people as described for Alternative B.

The added protection from abortions due to increasing the number of vaccinated bison is expected to result in an increase in bison calving rates and population growth. The decrease in seroprevalence could increase tolerance for bison to move to low-elevation winter ranges outside Yellowstone National Park.

Consequently, moderate to major adverse impacts could result in the short and long term because confinement and feeding may lead to food conditioning, disease transmission, and disruption of migratory patterns. Also, remote vaccination with increased time working around groups due to the added focus on adult females could alter bison behavior in a way that leads to aggression, avoidance of people, disruption of social bonds, and higher energy expenditures. Moderate to major beneficial impacts could result due to a reduction in abortions (i.e., brucellosis transmission) by vaccinated bison, and an increase in calving rates and population growth.

Cumulative Impacts
Anticipated cumulative impacts would be similar to those described in Alternative A.

Conclusion

Under Alternative C, negligible to minor adverse impacts could occur in the short term due to (1) removing some bison from the wild for research in captivity, (2) capturing other bison in the wild to monitor vital rates (pregnancy, survival), responses to vaccination, and/or other factors, and (3) injuries, infection, and stress sustained by bison during capture, confinement, physical restraint, and hand-syringe vaccination. The remote vaccination of young and adult female bison via biobullet could result in more tissue damage and a higher risk of bleeding and infection than Alternative B. Minor to moderate adverse impacts could result in the short and long term because confinement and feeding may lead to food conditioning, disease transmission, and disruption of traditional migratory patterns. Also, remote vaccination could alter bison behavior in a way that leads to aggression, avoidance of people, disruption of social bonds, and higher energy expenditures by some individuals responding to and avoiding the vaccine delivery teams.

Under Alternative C, minor beneficial impacts could occur over the long term (1) if new information from monitoring and research leads to advances in brucellosis suppression, a reduction in intensive management actions, and/or greater tolerance for wild bison in Montana. Moderate to major beneficial impacts could result in the long term (1) from vaccinating a larger portion (29%) of the population due to remote vaccination of young and adult female bison, (2) from bison receiving multiple vaccinations through their lives, thereby extending the duration of the vaccine-induced protective immune response, (3) if brucellosis prevalence in the population is reduced by about 66% due to a lower probability of transmission following vaccination, (4) if vaccinating and booster vaccinating young and adult female bison reduces future abortions by more vaccinated animals, and (5) if there is an increase in calving rates and population growth. However, remote delivery of vaccine would likely induce less of a protective immune response than hand-syringe vaccination (described for Alternative A). Also, bison will likely react (e.g., changes in behavior) to remote delivery, which could reduce the portion vaccinated over time. In addition, the absence of an easily distributed and highly effective vaccine and limitations of current remote delivery technologies (inconsistent vaccine hydrogel formulation; short rifle range) will reduce effectiveness. As a result, it is highly uncertain whether substantial brucellosis reduction can be achieved given (1) our limited understanding of bison immune responses to suppression actions such as vaccination, (2) the absence of an easily distributed and highly effective vaccine, and (3) limitations of diagnostic and vaccine delivery technologies.

Negligible to major adverse cumulative impacts could result from (1) the capture, confinement, and feeding of bison in Montana, (2) unintended harvest effects on bison demography and behavior, (3) livestock operations reducing tolerance for bison in some areas, (4) housing development fragmenting habitat or contributing to aggregations of bison that increase disease transmission and concentrate herbivory, (5) unintended effects of road grooming and winter recreation in Yellowstone that alter bison energy expenditures and behavior, (6) road and facility construction that disturb bison and their habitats, and (7) vehicle strikes and behavioral disturbances by visitors.

Negligible to major beneficial cumulative impacts could result from (1) the capture and vaccination of bison by the State of Montana that reduces brucellosis transmission risk, (2) increased tolerance for bison in Montana due to hunting and an administrative rule change that eliminated many economic barriers created by the brucellosis class system, (3) quarantine efforts that provide a source of live, brucellosis-free bison for relocation elsewhere, (4) grooming of roads in Yellowstone for winter recreation that save bison energy while traveling and provide better access to foraging habitats, and (5) visitors gaining an appreciation of bison that could result in enhanced support for their conservation as wildlife.

4.3 Other Wildlife, Including Threatened and Endangered 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 affected, while indirect impacts are possible for other species not in 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 IBMP members. 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 levels 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.
- *Minor*—impacts would be detectable, but would not be outside the natural range of variability. Small changes to population numbers, population structure, genetic variability, 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 populations would remain 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 (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 vaccinated bison 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 10).

Table 10. 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 FWS (Jones et al. 2006). Section 7 consultation was completed with a concurrence letter on the NPS determination of may affect, not likely to adversely affect, listed species provided to the park in January 2007 (Appendix H).

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

Since vaccination actions typically occur infrequently at the Stephens Creek facility (0 to 10 days per year), the adverse, direct, short term, and local impacts that create disturbance to wildlife behaviors would be negligible to minor. 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 haze them into 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.

Under Alternative A, the vaccination of bison helps prevent the already low probability of transmission of *Brucella abortus* from bison to other wildlife, including bald eagles, grizzly bears, and gray wolves, and represents a beneficial, indirect, long term, negligible to minor, and regional impact. Long-term impacts are expected to benefit many wildlife species that may be indirectly affected by exposure to *Brucella abortus* bacteria because the cumulative effects of vaccinating bison would result in a gradual decrease in exposure to brucellosis by other wildlife.

Yellowstone National Park has only one location where bison are captured. Direct impacts to federally listed species (Canada lynx, grizzly bears) or critical habitat (lynx) are not expected because (1) vaccination of bison is unlikely to occur in lynx habitat, (2) vaccination activities would likely result in only localized displacement of lynx and bears, and (3) there should be no associated injury or mortality to lynx or bears that consume carrion from bison vaccinated with SRB51.

Indirect impacts from vaccinated bison that are released from the holding facility and subsequently die within 24 weeks of vaccination are expected if those vaccinated bison still have vaccine strain *Brucella abortus* in their system. These carcasses, while few in number, would become possible vectors of exposure should predators or scavengers feed on them before they become 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 brucellosis 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 *Brucella 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 the warmer temperatures of spring time (Cook 1999, Aune et al. 2012). Some ungulates such as mule deer, white-tailed deer, and pronghorn have never been documented to harbor *Brucella abortus*. Four cases of brucellosis in wild moose were reported between 1937 and 1985 (Cheville et al. 1998). It is possible, but highly unlikely, that bacteria from vaccinated bison could be transmitted to other ungulates. Therefore, current transmission rates of *Brucella abortus* under Alternative A would have adverse, indirect, short term, negligible, and local 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 or vaccination activities on the landscape. Also, vaccination would have insignificant effects on the wolverine, which is proposed for listing as a federally threatened species, due to spatial separation in elevation and habitat between bison vaccination activities (primarily grasslands less than 2,400 meters elevation) and wolverine use areas (primarily areas with persistent snow cover greater than 2,440 meters elevation). In the unlikely event a lynx or wolverine encountered a carcass of a vaccinated bison that could be used as carrion, it would be less of a source of brucellosis infection than carcasses of bison infected with field strains of *Brucella* bacteria.

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 many of those listed for Yellowstone bison earlier in this chapter. Several of those 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.

While loss of habitat is occurring throughout the GYE, the primary impacts occurring from vaccination will be disturbance to other wildlife species. While localized effects have likely created negligible to minor adverse impacts, regionalized impacts to species have been moderate. The national parks and nearby wilderness areas have become more valuable to most wildlife species of the ecosystem because of the large expanse of high quality habitat. The GYE is renowned for its abundance of recreational opportunities. Human recreationists can create disturbances to wildlife that affect individuals or groups of individuals. Across the GYE these disturbances can accumulate 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 result 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, local, minor to moderate, adverse impacts in the form of disturbances to individuals of many wildlife species.

Conclusion

Negligible to minor beneficial impacts to other wildlife could occur in the short and long term because fewer bison would be transmission vectors of brucellosis to other animals. Negligible to minor adverse impacts could occur in the short and long term from disturbance and displacement of wildlife near the capture and vaccination operations. Negligible to minor beneficial impacts could occur to grizzly bears, lynx, and wolverines in the short and long term because fewer bison would be transmission vectors of brucellosis to these species. Negligible adverse impacts to grizzly bears, lynx, critical habitat for lynx, and wolverines are expected due to grizzly bears denning during most bison capture operations, and spatial separation between capture facilities and lynx and wolverine use areas. If these threatened species fed on a carcass of a vaccinated bison, it would be less of a source of brucellosis infection than carcasses infected with field strains of *Brucella*.

Negligible to major adverse cumulative impacts to other wildlife and/or federally threatened species could result from (1) unintended harvest effects on their demography and behavior, (2) livestock operations reducing tolerance for wildlife in some areas, (3) housing development fragmenting habitat or contributing to aggregations of wildlife that increase disease transmission and concentrate herbivory, (4) unintended effects of road grooming and winter recreation in Yellowstone that alter wildlife energy expenditures and behavior, (5) road and facility construction that disturb wildlife and their habitats, and (6) vehicle strikes and behavioral disturbances by visitors. Negligible to major beneficial impacts could result from (1) the capture and vaccination of bison and elk by the State of Montana that reduces brucellosis transmission risk, (2) grooming of roads in Yellowstone for winter recreation that save wildlife energy while traveling and provide better access to foraging habitats, and (3) visitors gaining an appreciation of wildlife that could result in enhanced support for their conservation.

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 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 park-wide vaccination operations would create adverse, direct, short term, minor to moderate 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 *Brucella abortus* from bison to other wildlife species by reducing the probability of bison shedding the bacteria. This would provide a beneficial, indirect, minor, long term, and regional 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 indirect, short term, minor, and local as a result of the short-term viability of the bacteria, low probability that any wildlife species would eat the projectile, and evidence that the vaccine does not create unacceptable clinical effects (e.g., abortions) in non-target species that were studied (Table 10). Vaccine doses are expected to get lost in the vegetation and disintegrate in the environment. Field studies indicate that *Brucella abortus* persistence decreases rapidly with increased ultraviolet exposure, heat, and dry conditions (Cook et al. 2004, Aune et al. 2012). Persistence of the vaccine would probably be limited to a few months or weeks depending on environmental conditions.

Remote vaccination would likely have negligible effects on lynx, critical habitat for lynx, and wolverine due to spatial separation in elevation and habitat between bison vaccination activities and lynx and wolverine use areas. Remote vaccination would also have negligible to minor effects on grizzly bears because activities would not occur in areas where bears are observed. In the unlikely event a grizzly bear, lynx, or wolverine was inadvertently exposed to a biobullet with vaccine, it would be less of a source of brucellosis infection than carcasses of bison infected with field strains of *Brucella* bacteria.

Cumulative Impacts

The cumulative impacts of implementing Alternative B on other wildlife species are similar to those described in Alternative A.

Conclusion
Negligible to minor beneficial impacts to other wildlife could occur in the short and long term because fewer bison would be transmission vectors of brucellosis to other animals. Negligible to minor adverse impacts could occur in the short and long term from disturbance and displacement of wildlife near the capture and vaccination operations. Negligible to minor beneficial impacts could occur to grizzly bears, lynx, and wolverines in the short and long term because fewer bison would be transmission vectors of brucellosis to these species. Negligible adverse impacts to grizzly bears, lynx, critical habitat for lynx, and wolverines are expected due to grizzly bears denning during most bison capture operations, and spatial separation between capture facilities and lynx and wolverine use areas. If these threatened species fed on a carcass of a vaccinated bison, it would be less of a source of brucellosis infection that carcasses infected with field strains of *Brucella*. The impacts would be more widespread than for Alternative A due to the implementation of park-wide remote vaccination. Remote vaccination activities would not occur in areas where bears are observed.

Negligible to major adverse cumulative impacts to other wildlife and/or federally threatened species could result from (1) unintended harvest effects on their demography and behavior, (2) livestock operations reducing tolerance for wildlife in some areas, (3) housing development fragmenting habitat or contributing to aggregations of wildlife that increase disease transmission and concentrate herbivory, (4) unintended effects of road grooming and winter recreation in Yellowstone that alter wildlife energy expenditures and behavior, (5) road and facility construction that disturb wildlife and their habitats, and (6) vehicle strikes and behavioral disturbances by visitors. Negligible to major beneficial impacts could result from (1) the capture and vaccination of bison and elk by the State of Montana that reduces brucellosis transmission risk, (2) grooming of roads in Yellowstone for winter recreation that save wildlife energy while traveling and provide better access to foraging habitats, and (3) visitors gaining an appreciation of wildlife that could result in enhanced support for their conservation.

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. A beneficial, indirect, long term, minor to moderate, and regional impact 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 and eating vaccinated bison that subsequently died, and by encountering (eating) missed doses of vaccine that were lost on the landscape. These impacts may increase over those expected under Alternative B, but are still expected to be short term and localized because encapsulated vaccine has a short life expectancy when exposed to ultraviolet light and heat. Also, available literature describing experimental exposure to non-target wildlife concluded that the vaccine does not create unacceptable clinical effects in non-target species (Table 10). 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.

Remote vaccination would likely have negligible effects on lynx, critical habitat for lynx, and wolverine due to spatial separation in elevation and habitat between bison vaccination activities and lynx and wolverine use areas. Remote vaccination would also have negligible to minor effects on grizzly bears because these activities would not occur in areas where bears are observed. In the unlikely event a grizzly bear, lynx, or wolverine was inadvertently exposed to a biobullet with vaccine, it would be less of a source of brucellosis infection than carcasses of bison infected with field strains of *Brucella* bacteria.

Cumulative Impacts

The types of cumulative impacts to other wildlife species from implementing Alternative C are similar to those described in Alternative A.

Conclusion

Negligible to minor beneficial impacts to other wildlife could occur in the short and long term because fewer bison would be transmission vectors of brucellosis to other animals. Negligible to minor adverse impacts could occur in the short and long term from disturbance and displacement of wildlife near the capture and vaccination operations. Negligible to minor beneficial impacts could occur to grizzly bears, lynx, and wolverines in the short and long term because fewer bison would be transmission vectors of brucellosis to these species. Negligible adverse impacts to grizzly bears, lynx, critical habitat for lynx, and wolverines are expected due to grizzly bears denning during most bison capture operations, and spatial separation between capture facilities and lynx and wolverine use areas. If these threatened species fed on a carcass of a vaccinated bison, it would be less of a source of brucellosis infection that carcasses infected with field strains of *Brucella*. The impacts would be more widespread than for Alternative A due to the implementation of park-wide remote vaccination. Remote vaccination activities would not occur in areas where bears are observed.

Negligible to major adverse cumulative impacts to other wildlife and/or federally threatened species could result from (1) unintended harvest effects on their demography and behavior, (2) livestock operations reducing tolerance for wildlife in some areas, (3) housing development fragmenting habitat or contributing to aggregations of wildlife that increase disease transmission and concentrate herbivory, (4) unintended effects of road grooming and winter recreation in Yellowstone that alter wildlife energy expenditures and behavior, (5) road and facility construction that disturb wildlife and their habitats, and (6) vehicle strikes and behavioral disturbances by visitors. Negligible to major beneficial impacts could result from (1) the capture and vaccination of bison and elk by the State of Montana that reduces brucellosis transmission risk, (2) grooming of roads in Yellowstone for winter recreation that save wildlife energy while traveling and provide better access to foraging habitats, and (3) visitors gaining an appreciation of wildlife that could result in enhanced support for their conservation.

4.4 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 levels 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.

Impacts from Alternative A—NPS Preferred Alternative (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. Moreover, some American Indian tribes have expressed that vaccination programs will contaminate the spirit of the local bison.

Implementation of Alternative A causes concern to some 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 such as elk are also infected with brucellosis but not subjected to vaccination or other management actions similar to Yellowstone bison. Some American Indians have expressed that Yellowstone bison are being discriminated against in the same manner that native peoples 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 hunting on some federal lands adjacent to the park may be adversely affected if some members believe that vaccination contaminates bison for the purposes of consuming the meat or using parts in their ceremonies. Therefore, impacts could be adverse, direct or indirect, short or long term, minor to moderate, and local to regional.

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 impacts from vaccinating the Yellowstone bison population will not significantly reduce numbers or distribution of bison. However, long-term beneficial impacts may occur if the program is successful in decreasing the prevalence of brucellosis in the population, which in turn, could increase the probability that brucellosis-free bison may be eligible for live transfer to tribes associated with Yellowstone National Park, as many tribes have requested.

Cumulative Impacts

Alternative A would likely have minor adverse and beneficial cumulative effects (similar to the direct and indirect effects described above) on ethnographic resources. Adverse cumulative effects on ethnographic resources may occur due to the belief of some tribes that continued human intervention through vaccination, capturing and handling of bison causes undue stress on the animals and harms the spirit of the bison. Tribal hunting on some federal lands adjacent to the park may also to be adversely affected if some members believe that vaccination contaminates bison for the purposes of consuming the meat or using parts in their ceremonies. Beneficial impacts may occur due to the potential overall decrease in the prevalence of brucellosis in the bison population, thus providing healthy bison herds for harvesting outside of the park and live transfer of bison to tribes associated with the park.

Conclusion
Minor to moderate adverse impacts could result in the short and long term because capture and vaccination operations are offensive to some American Indians and some tribes in general. Also, bison should not be consumed for 21 days after vaccination. Thus, vaccinated bison are held in the capture facility and not allowed to migrate into Montana where treaty harvests occur. Minor to moderate beneficial impacts could result if vaccination contributes to decreasing brucellosis prevalence, which in turn, could increase bison productivity and contribute to more brucellosis-free bison for harvest and transfer to tribal lands. Cumulative impacts are anticipated to be minor adverse and beneficial.

Impacts from Alternative B (Remote-Delivery Vaccination—Young Bison Only)
The impacts of Alternative B would be similar to those described for Alternative A, except that a larger proportion of the bison population would be vaccinated. The impacts of vaccination that create reduced value of Yellowstone bison by some tribal members are adverse, direct and indirect, short and long term, and moderate to ethnographic resources regionally. However, after the implementation of park-wide remote vaccination of young bison there may be greater access to brucellosis-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 brucellosis-free can be formalized and allow surplus Yellowstone bison to be consigned as live animals to bison-interested tribes.

Cumulative Impacts
Cumulative impacts would be similar to those described under Alternative A.

Conclusion
Moderate adverse and beneficial impacts from this alternative include those disclosed for Alternative A. However, the impacts could be more extensive and widespread due to the implementation of park-wide remote vaccination. Cumulative impacts are anticipated to be minor adverse and beneficial.

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 impacts of vaccination that affect values about Yellowstone bison by some tribal members would be adverse and beneficial, direct and indirect, short and long term, and moderate 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 would be similar to those described under Alternative A.

Conclusion
Moderate adverse and beneficial impacts from this alternative include those disclosed for Alternative A. However, the impacts could be more extensive and widespread due to the implementation of park-wide remote vaccination. Cumulative impacts are anticipated to be minor adverse and beneficial.

4.5 Human Health and Safety

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* 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 wildlife biologists, veterinarians, cattlemen, and slaughterhouse workers (Luce et al. 2012). Hunters in areas of endemic brucellosis (GYE and southeastern United States) can be at higher risk if they are careless in field dressing their game (Luce et al. 2012). 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.

In March of 2005, eight NPS employees from Yellowstone and Grand Teton National Parks voluntarily provided blood samples to the Wyoming Department of Health and Centers for Disease Control and Prevention as part of a survey to estimate brucellosis (*Brucella abortus*) seroprevalence and identify risk factors for infection of persons working in professions at high risk for exposure. Yellowstone National Park contacted the survey administrator a year later to request the results of the survey for NPS employees and were verbally informed by phone that none of the blood samples provided by NPS employees were identified as reacting positively for *Brucella* exposure (Wyoming Department of Health 2006). None of the NPS participants were subsequently contacted by the Wyoming Department of Health and Centers for Disease Control and Prevention to be made aware of the status of their blood tests. However, at a 2009 meeting of the Wyoming Governor's Brucellosis Coordination Team, it was verbally reported that four of eight NPS employees in the 2005 survey had measurable titers for brucellosis exposure. Subsequently, the NPS requested and received a copy of a draft manuscript on the survey entitled *Brucellosis Seroprevalence among Workers in At-Risk Professions – Northwestern Wyoming, 2005-2006* that reiterated these results and stated that NPS workers were at increased risk for a measurable *Brucella* titer.

The NPS was surprised by these reports because none of the employees that participated in the 2005 survey were notified of a positive *Brucella* titer and it is highly improbable that mailed results were returned as undeliverable when five of eight surveyed employees still worked at Yellowstone and Grand Teton National Parks in 2009. Also, when the NPS requested that the Wyoming Department of Health re-send test results to NPS employees, they were informed that the original survey sheets had been destroyed and there was no way to link a positive test result to a name without those survey sheets. In addition, the NPS was informed that no cross-reactivity tests were conducted during the 2005 survey, even though the *Brucella* antibody titers reported for the four NPS employees supposedly testing positive were within the range of detection for other cross-reacting antibodies. *Brucella* titers can cross-react with other diseases/pathogens, including tularemia, plague, and *E*scherichia *coli*, thereby causing false-positive test results for *Brucella* antibodies. The NPS notified the Centers for Disease Control and Prevention of these concerns in an August 20, 2009 letter (Yellowstone National Park 2009), but the findings were later published without further clarification or explanation (Luce et al. 2012).

The NPS is committed to protecting employee health. In coordination with the U.S. Public Health Service office at Yellowstone National Park, vigilant brucellosis worker safety protocols and medical monitoring are implemented that include prophylactic measures, baseline and periodic testing of higher-risk employees, and successive testing of employees disclosing illness following handling potentially infected wildlife. Employees working for the Bison Ecology and Management Program at Yellowstone have been periodically tested for *Brucella* exposure since 2002 by having blood samples drawn and submitted to the Montana Public Health Laboratory, which uses essentially the same test for *Brucella* antibodies as used during the 2005 Wyoming survey. Employees working in this program have been tested several times (6 staff in 2002, 7 staff in 2005, 4 staff in 2007, 6 staff in 2008, and 6 staff in 2011) for *Brucella* exposure since the 2005 Wyoming survey, and no employees have disclosed receiving notice of a positive test for *Brucella* antibodies.

For the 2005 survey, it appears that the Wyoming Department of Public Health will not be able to identify or validate NPS employees that reportedly had positive titers for *Brucella* antibodies in 2005 and, without additional information, it is unclear if the reported *Brucella* antibody titers were associated with NPS work activities, associated with previous high-risk work activities, or misclassified (e.g., cross reactions). Thus, the NPS does not support the findings of the 2005 Wyoming survey. The NPS will remain vigilant to the risks of zoonotic brucellosis among our work force and committed to working with local, regional, and national public health partners to ensure employee health.

The levels 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.

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

The direct impacts of implementing Alternative A are adverse, indirect, short term, minor to moderate (moderate if antibiotics are required), and localized at the Stephens Creek capture facility. These impacts would be accidental exposure of *Brucella 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). Safety briefings are a part of each day's operations and all individuals continuously evaluate the safety risks for themselves and their colleagues. 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 a bison move about in the handling chute more quickly than staff could react and retract their hands.

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. The agency 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. The NPS will recommend that hunters do not consume harvested meat if a bison is killed within 21 days of being vaccinated. The NPS will continue to notify state wildlife agencies and American Indian tribes with recognized treaty harvest rights near Yellowstone of forthcoming vaccination efforts through established working groups and communications networks. If hunters consume meat exposed to SRB51 within this 21-day window, they may be exposed to the vaccine and experience symptoms of human brucellosis (undulant fever), as described in Section 1.1. However, transmission via vaccine is very rate. Thus, impacts would be adverse, indirect, short-term, minor to moderate, and local to regional given a positive response to antibiotic treatment.

Vaccination of bison is conducted to reduce the rate of abortion and the number of bison infected with brucellosis. Such reductions would indirectly reduce the exposure risk to those humans most likely to encounter the bacteria (veterinarians; wildlife workers conducting necropsies or collecting tissues for research and monitoring; hunters; and slaughterhouse workers). Thus, vaccination would result in a beneficial, indirect, short and long term, minor to moderate, and local to regional impact to some humans through reduced risk of brucellosis transmission. No impacts to visitors are expected because the vaccination period is relatively short and the area (Stephens Creek) used to capture and process bison is closed to public entry.

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 outside the 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).

There are many inherent health and safety challenges for humans that work or pursue recreational interests in Yellowstone National Park, 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. Overall, the cumulative effects are anticipated to be negligible to minor for health and safety.

Conclusion
Minor to moderate adverse impacts could result in the short and long term if humans (1) are accidentally exposed to the vaccine and/or become sick or injured during handling of vaccine and/or bison, or (2) consume meat that has vaccine residue in it. Minor to moderate beneficial impacts could occur if vaccination reduces the number of infected bison, and consequently, the exposure risk to humans most likely to encounter the bacteria (hunters, wildlife biologists, slaughter house workers, and veterinarians). Cumulative effects would be negligible to minor for health and safety.

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 park-wide remote delivery activities would constitute a slightly higher degree of human health and safety concern 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. 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 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 bison will not be physically handled. Also, reducing the rate of abortion and the number of bison infected with brucellosis would indirectly reduce the exposure risk to those humans most likely to encounter the bacteria. Overall, impacts would be adverse and beneficial, direct and indirect, short and long term, minor to moderate, and local. No impacts to visitor safety are expected.

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. Meat from animals vaccinated with SRB51 should not be consumed at least until after this time period has elapsed. If notifications on meat consumption are ignored, given the possibility that more vaccinated bison would be available to hunters, impacts would be adverse, indirect, short term, moderate, and regional. Mitigation measures will be implemented to remotely vaccinate bison in areas distant from impending or ongoing hunting to avoid or minimize human health concerns regarding the harvest of recently vaccinated bison.

<u>Cumulative Impacts</u>

The cumulative impacts to human health and safety risks are similar to those described under Alternative A. 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 *Brucella 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 have mitigated the human health and safety risks for the State of Wyoming personnel.

Conclusion

Minor to moderate adverse and beneficial impacts from this alternative include those disclosed for Alternative A. However, the impacts could be more extensive and widespread due to the implementation of park-wide remote vaccination. Also, it is uncertain how many hunters would be exposed to remotely vaccinated bison since these animals would not be held in captivity during the vaccine withdrawal time (when their meat should not be eaten). Past, present, and reasonably foreseeable actions occurring within the park and the surrounding area that would be expected to contribute to cumulative impacts on human health and safety include all activities presented earlier in this chapter in sections 4.2 and 4.3, as well as the many inherent health and safety challenges for humans that work or pursue recreational interests in Yellowstone National Park.

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. Implementation of Alternative C would increase the time personnel spend in close proximity to wild bison while implementing the vaccination program. 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, then hunters could be exposed to more vaccinated bison. Reducing the number of bison infected with brucellosis would indirectly reduce the exposure risk to humans. No impacts to visitor safety are expected.

<u>Cumulative Impacts</u>

The cumulative impacts to human health and safety risks are similar to those described above under Alternatives A and B.

Conclusion

Minor to moderate adverse and beneficial impacts from this alternative include those disclosed for Alternative A. However, the impacts could be more extensive and widespread due to the implementation of park-wide remote vaccination. Also, it is uncertain how many hunters would be exposed to remotely vaccinated bison since these animals would not be held in captivity during the vaccine withdrawal time (when their meat should not be eaten). Past, present, and reasonably foreseeable actions occurring within the park and the surrounding area that would be expected to contribute to cumulative impacts on human health and safety include all activities presented earlier in this chapter in sections 4.2 and 4.3, as well as the many inherent health and safety challenges for humans that work or pursue recreational interests in Yellowstone National Park.

4.6 Visitor Use and Experience

Impacts to visitor use and experience were assessed by determining the current condition of visitor use and experience inside Yellowstone National Park that was likely to be affected by the alternatives, and by identifying the potential impacts from a vaccination program implemented under each alternative.

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, 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 levels 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. Many 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 natural and cultural resources, as well as their ability 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).

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

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 800 hectares 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. Bison capture and vaccination could be perceived as adverse or beneficial depending on the personal perspectives of visitors about wildlife conservation and disease management. Given the limited area for vaccination under Alternative A, impacts to visitor experience and safety would be adverse and beneficial, direct and indirect, short term, negligible to minor, and local.

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 on visitor use and experience include other capture and 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 could implement a similar capture and vaccination program outside Yellowstone National Park. In addition, the state and several American Indian tribes with treaty hunting rights manage bison hunting programs that occur on lands adjacent to Yellowstone National Park. Bison capture and harvest can impact visitors when they encounter those activities, with inputs being adverse or beneficial depending on personal perspectives about bison conservation or reducing brucellosis infection in bison through vaccination.

Conclusion

Negligible to minor adverse impacts could result in the short term because visitors would not have access to about 800 hectares of the Gardiner basin. Also, some visitors would be annoyed about the handling, confinement, and vaccination of bison. Negligible to minor beneficial impacts could result because some individuals would appreciate attempts to reduce brucellosis prevalence in bison and the risk of transmission to cattle. Past, present, and reasonably foreseeable actions occurring within the park and the surrounding area that would be expected to contribute to cumulative impacts on visitor use and experience include all activities presented earlier in this chapter in sections 4.2 and 4.3, as well as the many recreational opportunities for visitors in the GYE.

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 vaccination operations would increase under Alternative B. For remote-vaccine delivery to be successful there needs to be limited activities occurring in the vicinity of individual bison groups being vaccinated. 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 observing or 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. Impacts could be beneficial for those visitors that support the protection of Montana's cattle industry and maintaining its brucellosis class-free status.

The wounding of a bison during vaccine delivery is possible, but the probability appears 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 adverse, indirect, short term, minor, and local on visitor use opportunities and associated experiences.

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 remote-delivery vaccination crews as the program progresses is uncertain. The consistent pressure of being vaccinated by field crews may result in bison avoiding people and altering their behavior in a way that could lead to fewer viewing opportunities by visitors. There is no information on how bison will react to being vaccinated with this remote method over a long time period. Therefore, adverse, direct and indirect, short and long term, minor to major, and regional impacts influencing bison tolerance for people and visitor viewing opportunities may result from consistent remote vaccination pressure.

<u>Cumulative Impacts</u>

The cumulative impacts to visitor use and experience are similar to those described above under Alternative A.

Conclusion

Minor to major adverse and beneficial impacts from this alternative include those disclosed for Alternative A. However, the impacts could be more extensive and widespread due to the use of park-wide remote vaccination. Remote vaccination would result in additional injuries, the marking of more bison, and more than likely, changes in bison behavior (avoidance of people) that reduce visitor viewing opportunities. Impacts could be beneficial for visitors that support the protection of Montana's cattle industry and maintaining its brucellosis class-free status. Past, present, and reasonably foreseeable actions occurring within the park and the surrounding area that would be expected to contribute to cumulative impacts on visitor use and experience include all activities presented earlier in this chapter in sections 4.2 and 4.3, as well as the many recreational opportunities for visitors in the GYE.

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. 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. Also, there is no information on how bison will react to being vaccinated with this remote method over a long time period. Therefore, minor to major, indirect, adverse, short and long term impacts influencing bison tolerance for people and visitor viewing opportunities may result from consistent remote vaccination pressure.

Cumulative Impacts

The cumulative impacts to visitor use and experience are similar to those described above under Alternative A.

Conclusion

Minor to major adverse and beneficial impacts from this alternative include those disclosed for Alternative A. However, the impacts could be more extensive and widespread due to the use of park-wide remote vaccination. Remote vaccination would result in additional injuries, the marking of more bison, and more than likely, changes in bison behavior (avoidance of people) that reduce visitor viewing opportunities. Impacts could be beneficial for visitors that support the protection of Montana's cattle industry and maintaining its brucellosis class-free status. Past, present, and reasonably foreseeable actions occurring within the park and the surrounding area that would be expected to contribute to cumulative impacts on visitor use and experience include all activities presented earlier in this chapter in sections 4.2 and 4.3, as well as the many recreational opportunities for visitors in the GYE.

4.7 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 levels 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.

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

Implementation of Alternative A would be localized at and near the Stephens Creek corral and holding paddocks northwest of Gardiner, Montana. 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. No additional staff would be needed for implementing Alternative A. Personnel conduct hazing and capture operations, and operate capture facility trap and squeeze chute gates to sort bison for age-specific vaccination. Workload also includes collaborative efforts to handle groups of bison, care for individuals that are held in the facility, purchasing supplies needed for vaccination, and regular maintenance of the facility to keep it safe for humans and 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, IBMP members, and public interest groups and individuals.

Implementation of Alternative A will have some beneficial impacts by providing new information 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 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. Budget and staffing would remain at or near current levels. Cumulative impacts under Alternative A would be negligible to minor due to staffing needs and infrastructure support for activities proposed under this alternative when combined with past, present and future forseeable actions.

Conclusion

Negligible to minor adverse impacts could result in the short and long term from maintenance needs to keep the capture facility in good repair, staffing needs to support the hazing, capture, vaccination, and monitoring of bison, and staff time and effort to respond to requests from other agencies, media, tribes, and stakeholder groups or individuals. Negligible to minor beneficial impacts could result from providing new information that increases understanding of the implications and effects of managing and vaccinating bison, which could be used to address social conflicts related to bison. Past, present, and reasonably foreseeable actions occurring within the park and the surrounding area that would be expected have negligible to minor cumulative impacts on park operations when combined with all activities presented earlier in this chapter in sections 4.2 and 4.3, as well as the many inherent services provided for humans that work or pursue recreational interests in Yellowstone National Park.

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

The impacts to park operations from implementation of Alternative B would include those described for Alternative A, except that park-wide remote delivery would constitute a slightly higher degree of concern. Overall, implementation of Alternative B would have adverse and beneficial, direct and indirect, short and long term, minor to moderate, and local and regional impacts on park operations. These impacts would affect the Bison Ecology and Management Program more than any other work group in the park. Staff would be required to maintain high skill levels in operating specialized equipment, handling and documenting use of vaccine, and conducting research and monitoring efforts needed to evaluate the effects and effectiveness of the program. Safety and skill training would be persistent and long-term. The bison management staff would also have to communicate with area management partners and the National Brucellosis program administered by the Washington Office of USDA.

Remote delivery will be conducted by relatively few staff on only one or two groups of bison at a time, and 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 the roads are closed to the public if they 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.

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

Another long-term 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 IMBP members could take a new perspective as seroprevalence in the population decreased, thereby providing the potential for new management opportunities.

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 such as 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 the 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, and short-term work delays due to remote vaccination operations could result.

Remote-delivery vaccination of calves and yearling female bison may occur during April through June, when 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 that day. NPS staff will also avoid locations with ungulate carcasses that are being used by grizzly bears. These adjustments to workload and schedules should be minor and short term.

<u>**Cumulative Impacts**</u>

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 the 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.

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 adverse impacts would be minor to moderate because of the increased complexity and cost of the program. The number of vaccines delivered remotely by staff is expected to increase and become more efficient as staff gain more experience in conducting this program.

Conclusion

Minor to moderate adverse and beneficial impacts from this alternative include those disclosed for Alternative A. However, the impacts would be more extensive and widespread due to the use of park-wide remote vaccination. Some park staff would be required to learn and implement new skills and technologies. Also, there could be occasional traffic delays due to remote vaccination. Furthermore, there would be additional levels of inquiry, increased reporting requirements, and additional duties by some park staff related to vaccine encapsulation. Past, present, and reasonably foreseeable actions occurring within the park and the surrounding area that would be expected to minor to moderate adverse cumulative impacts on park operations when combined with all activities presented earlier in this chapter in sections 4.2 and 4.3, as well as the many inherent services provided for humans that work or pursue recreational interests in Yellowstone National Park.

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. Overall, implementation of Alternative C would have adverse and beneficial, direct and indirect, short and long term, moderate to major, and local to regional impacts on park operations. 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. The increased number of bison to be vaccinated would mostly affect the Bison Ecology and Management Program. Bison management staff would also have to communicate with area management partners and the National Brucellosis Program administered by the Washington Office of USDA.

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 brucellosis responses to the remote vaccination program would require increased, long-term funding or cessation of other monitoring currently being conducted.

The labor needed for staff to deliver more vaccine to a larger proportion of the bison population under Alternative C would have a long-term, moderate to major impact on workload 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 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, beneficial impact of Alternative C compared to Alternative B is that seroprevalence in the bison population should decrease faster. Thus, management discussions with IBMP members should advance due to new management opportunities resulting from decreases in population seroprevalence.

<u>**Cumulative Impacts**</u>

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.

Conclusion
Minor to moderate adverse and beneficial impacts from this alternative include those disclosed for Alternative A. However, the impacts would be more extensive and widespread due to the use of park-wide remote vaccination. Some park staff would be required to learn and implement new skills and technologies. Also, there could be occasional traffic delays due to remote vaccination. In addition, there would be additional levels of inquiry, increased reporting requirements, and additional duties by some park staff related to vaccine encapsulation. Past, present, and reasonably foreseeable actions occurring within the park and the surrounding area that would be expected to minor to moderate adverse cumulative impacts on park operations when combined with all activities presented earlier in this chapter in sections 4.2 and 4.3, as well as the many inherent services provided for humans that work or pursue recreational interests in Yellowstone National Park.

4.8 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 Operating Procedures for the plan. 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 alternative. The adaptive management approach of the plan incorporates monitoring and research to answer uncertainties, make improvements, and attain reasonable assurances of success before implementing a costly, long-term remote vaccination of bison park-wide.

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

While the hand-syringe vaccination of calves and yearlings in Alternative A, and the syringe and remote vaccination of calves and yearlings in Alternative B, will lead to some negligible to moderate, adverse impacts, a successful long-term reduction in the risk of brucellosis transmission could enhance the long-term sustainability and management options for bison.

Long-term enhancement would be increased under Alternative C because remote vaccination would include adult females. If successful, this additional effort could lead to a major, long-term benefit toward bison conservation. Repeated vaccination of individual bison could result in long-term vaccination protection for the population and help to sustain a higher level of population immunity, in turn leading to higher levels of calf production and increased tolerance for bison on ranges outside Yellowstone National Park. As a result, long-term conservation of the population may improve. However, it is highly uncertain whether substantial brucellosis reduction can be achieved given (1) our limited understanding of bison immune responses to suppression actions such as vaccination, (2) the absence of an easily distributed and highly effective vaccine, and (3) limitations of diagnostic and vaccine delivery technologies.

4.10 Adverse Impacts That Could Not Be Avoided

Under all alternatives, impacts to individual bison and other wildlife that directly contact vaccine strain *Brucella abortus* are unavoidable. Likewise, adverse impacts to individual humans that disapprove of wildlife vaccination are unavoidable. For each alternative, 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.

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 during August 16-18, 2005. The NPS 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:

- Managers should dramatically increase the use of established brucellosis vaccines in elk, bison, and cattle in the GYE.
- Research scientists should move forward with experiments to evaluate the effectiveness of novel existing vaccines in cattle, bison, and elk.
- 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 issues related to the feasibility of implementing an in-park program for delivering vaccine to free-ranging Yellowstone bison and described a quantitative model for estimating the relative impacts each vaccination alternative would have on population seroprevalence (Wallen et al. 2005).

In addition, in February 2013 the NPS and Montana Fish, Wildlife & Parks invited scientists from federal, state, academic, and non-governmental entities to (1) review what is known about the vaccine-induced immune responses of bison and elk, (2) review the benefits and limitations of existing tools and emerging technologies for suppressing brucellosis prevalence in Yellowstone bison and elk, (3) evaluate whether substantial brucellosis suppression is feasible and sustainable without significantly affecting bison behavior or visitor experience, and (4) provide guidance for the future direction of brucellosis suppression activities (including suitable tools, research, and surveillance), considering that the primary mission of the park is to preserve its natural and cultural resources for the benefit of the American people. At the close of the workshop, the panel provided a summary, including:

- To date, management to maintain separation between cattle and bison appears to be effective at preventing transmission of brucellosis between these species because no documented transmission has occurred under the IBMP.
- The best available data do not support that vaccination of wild bison with currently available vaccines will be effective at suppressing brucellosis to a level that changes bison management strategies under the IBMP (USDI, NPS and Montana Fish, Wildlife & Parks 2013).

Internal Scoping

The IBMP directed the expansion of an in-park 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 vaccine delivery program?

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 vaccination program 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.

Public Scoping

Public scoping for the bison vaccination program was initiated in August 2004 when the Notice of Intent to Prepare an EIS was published in the Federal Register (USDI, NPS 2004). 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. 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. 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 and a total of 37 people attended public meetings. Most of the 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.

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). 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.

Public Meetings and Outreach

The notice of availability for the DEIS was published in the *Federal Register* in May 2010 (USDI, NPS 2010a). The original comment period was from May 28, 2010 to July 26, 2010. The NPS announced the reopening of the public comment period in the *Federal Register* in September 2010 (USDI, NPS 2010b). The NPS indicated they would accept any comments received between the original comment period end date of July 26, 2010 and September 24, 2010.

The NPS conducted three public meetings to gain information from the public on the park's purpose and significance, issues, and alternatives presented in the DEIS. These meetings were held in Bozeman, Montana on June 14, 2010, Helena, Montana on June 15, 2010, and Malta, Montana on June 16, 2010. Yellowstone's public information office issued a news release to describe specific dates and locations for the public meetings. The meetings were attended by a total of 106 people. Also, information about the planning process and how to comment about this process was available through the Yellowstone National Park web site.

The NPS received a total of 1,644 correspondences via letters, electronic mail (email), faxes, comments from public meetings, park forms, web forms submitted via the NPS's Planning, Environment and Public Comment website (PEPC), and other sources. These correspondences were distilled into 9,410 individual comments. From this correspondence, the NPS in collaboration with Weston Solutions, Inc. identified 6,629 substantive comments, which were divided into 26 concern statements. Substantive comments are those that are not simple statements for or against the proposal, but rather those comments requiring additional explanation or analysis of data and those that questioned facts or conclusions contained in the DEIS. Substantive comments are addressed in Appendix B.

Most respondents associated with conservation constituencies opposed the remote vaccination program and recommended vaccination of cattle rather than bison. Conversely, most respondents associated with livestock groups supported vaccination (Alternative C). Many respondents suggested that the projected cost of park-wide remote vaccination was too expensive to justify the benefits. A few constituency groups initiated letter writing campaigns to suggest re-directing funding to purchase grazing opportunities from private landowners outside Yellowstone National Park. Many respondents disputed the scientific information presented in the DEIS or suggested that inadequate scientific information existed to justify a decision to implement remote vaccination.

Agency and American Indian Consultation and Coordination

Pursuant to Section 7 of the Endangered Species Act of 1973, as amended, the NPS initiated consultation with the FWS 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 FWS 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 FWS concurred with this assessment in January 2007 (Appendix H). The bald eagle and the gray wolf have since been removed from the federal List of Endangered and Threatened Wildlife and Plants.

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 DEIS. 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 in December 2006 (Appendix D).

Five federal and state agencies are responsible for implementing the IBMP—the NPS; Animal and Plant Health Inspection Service, United States Forest Service, Montana Department of Fish, Wildlife, and Parks, and Montana Department of Livestock. Prior to, and during the course of drafting and releasing the FEIS for the IBMP (USDA and USDI 2000a), the federal agencies conducted government-to-government consultations with American Indian tribes, as described in Volume 1, Appendix H of that document. The Confederated Salish and Kootenai Tribe, Nez Perce Tribe, and InterTribal Buffalo Council became IBMP members in 2009. The NPS has briefed the other IBMP members several times per year at public meetings on progress related to the decision whether to implement remote vaccination of bison in Yellowstone National Park (see website at <ibmp.info>).

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 vaccination on Yellowstone bison. Also, during May 2010 letters requesting comments on the DEIS were sent to 73 American Indian tribes and the InterTribal Buffalo Council, which is a federally chartered organization of 56 member tribes committed to reestablishing buffalo populations on Indian lands.

5.2 Preparers and Consultants

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Other Collaborators

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. 2007). Significant contributors during this process were:

Mr. Keith Aune, Director of Wildlife Research, Montana Fish, Wildlife & Parks, Helena, Montana
Dr. Phillip Elzer, Professor, School of Animal Sciences (Infectious Diseases), Louisiana State University, Baton Rouge, Louisiana
Dr. John Gross, Wildlife Biologist, NPS, Fort Collins, Colorado
Dr. Terry Kreeger, Wildlife Veterinarian, Wyoming Game and Fish, Wheatland, Wyoming
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Dr. Steven Sweeney, Wildlife Veterinarian, Bozeman, Montana
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In February 2013, the NPS and Montana Fish, Wildlife & Parks invited scientists from federal, state, academic, and non-governmental entities to review existing tools and emerging technologies for suppressing brucellosis prevalence in bison and elk, and evaluate whether substantial brucellosis suppression is feasible and sustainable without significantly affecting bison behavior or visitor experience. The members of this science panel were:

Mr. Keith Aune, Senior Conservationist, Wildlife Conservation Society, Bozeman, Montana
Dr. John Cox, Adjunct Assistant Professor of Wildlife and Conservation Biology, Department of Forestry, University of Kentucky, Lexington, Kentucky

Dr. Vanessa Ezenwa, Associate Professor, Department of Infectious Diseases, College of Veterinary Medicine, University of Georgia, Athens, Georgia
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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.

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

Antibody: a protein molecule produced after exposure to an infectious agent (bacteria or virus) that can combine specifically with that agent (antigen).

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

Bacterium: any of the unicellular prokaryotic microorganisms of the class Schizomycetes, which vary in terms of morphology, oxygen and nutritional requirements, and motility.

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 bison may be tolerated for part or all of the year without increasing the risk of brucellosis transmission to cattle.

Carrion: dead and putrefying flesh.

Clinical sign: a sign or symptom of a disease.

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.

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

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

Density-dependent: a response, in wildlife populations, that occurs when there are a high number of individuals within a given area.

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

Dispersal: movement from one area to another without returning shortly thereafter.

Dose: a prescribed amount of medication or vaccine.

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

Efficacious vaccine: a substance that effectively stimulates a protective immune system response.

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

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 introduction of an infectious disease organism into 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, such as 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.

Greater Yellowstone ecosystem: the general location where the states of Idaho, Montana, and Wyoming share a boundary; measuring roughly 400 kilometers north-to-south and 200 kilometers east-to-west.

Host: a living animal or plant on or in which a disease or 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.

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.

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

Intracellular pathogens: a disease-causing organism that operates within the cell walls of 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 that is a part of the lymphatic system. They are found throughout the body and act as filters or traps for foreign particles. They contain white blood cells and 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.

Migration: seasonal, round-trip movements between separate areas not used at other times of the year.

Mortality: death; 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.

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.

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.

Range expansion: the outward dispersal of animals beyond the limits of the traditional distribution for a population.

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

Remote delivery: 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, which 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.

Stakeholders: people and organizations that use, influence, and/or have an interest, or stake, in a given resource.

Statistical difference: a quantitative difference between two sampled populations.

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

Susceptible: capable of being affected.

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

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 Malta fever; brucellosis in 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.

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Appendix A: 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.

National Park Service Enabling Legislation

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."

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."

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.

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."

General Legislation and Regulations

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).

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.

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 2,020 hectares 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.

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.

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.

Natural Resources Legislation

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.

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.

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 FWS, 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 FWS 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 FWS during the planning process.

Cultural Resources Legislation

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.

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.

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.

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.

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.

Executive Orders

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.

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.

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).

Appendix B: Responses to Public Comments

The DEIS entitled Brucellosis Remote Vaccination Program for Bison for Yellowstone National Park was released for public review and comment on May 28, 2010. The public comment period was originally scheduled to end on July 26, 2010, but due to requests from several groups, the comment period was extended by 60 days to end on September 24, 2010. Documents were accepted until October 9, 2010 to accommodate for delivery delays.

Many respondents provided comments on a much broader perspective of management philosophy regarding how to manage Yellowstone bison and the merits of the IBMP. In some cases, comments completely failed to address the purpose and need for the action described in the DEIS. Several constituency groups conducted letter writing campaigns that generated a large number of comments for or against particular alternatives without providing substantial comments that helped the NPS evaluate the merits of implementing an in-park remote vaccination program.

The majority of respondents overwhelmingly opposed the remote vaccination program for bison based on their values and indicated a preference for protecting cattle through vaccination and/or eliminating livestock. Most of these respondents did not think it was appropriate to vaccinate wildlife in national parks and opposed any vaccination program to reduce brucellosis infection in Yellowstone bison. Many respondents thought the projected cost of remote vaccination was too high. Many proponents of vaccination supported implementation of Alternative C, while opponents thought the cost would not justify the benefits to bison. Few respondents acknowledged that controlled scientific experiments show vaccinated bison express greater ability to fend against infection than bison that are not vaccinated. One livestock stakeholder group indicated there would be greater tolerance for bison on ranges outside the park if they knew bison managers were actively pursuing ways to reduce brucellosis infection in Yellowstone bison. Also, some comments provided information about uncertain parameters that assisted the NPS in confirming the full suite of uncertainties that need to be evaluated so new information can be accumulated through management, monitoring, and research.

Definition of Terms

The following key terms were used in analyses of and responses to public comments (*The Public Comment and PEPC Step 7: Managing the Comment Analysis Process User Guide*. March 2008. PEPC Glossary at https://pepc.nps.gov/help/glossary.cfm):

- *Correspondence*: Any format of feedback received from the public.
- *Master form letter*: The first correspondence received for a form letter campaign or the most appropriate example that contains the most text entirely unaltered from the source. Other correspondence with identical content can be designated as form letters under this template so that the correspondence only needs to be analyzed and coded once.
- *Code*: Used to represent a topic or subject matter with which the public is concerned. A code is used to organize similar comments under one topic that represents specific subject matter.
- *Comment*: Text selected from correspondence and coded to a particular topic or subject.
- *Representative quote*: A comment that exemplifies many other comments under a specific code.

- *Concern*: A statement that summarizes comments by the public.

Methods

The NPS analyzed correspondence regarding the DEIS to identify and respond to topics that were of concern to the public. Correspondence was analyzed using the following steps:

- Aggregate and catalog correspondence using the Planning, Environment, and Public Comment (PEPC) website;
- Analyze correspondence and extract individual comments;
- Develop coding structure and assign codes to comments;
- Identify common themes of comments to categorize issues and devise concern statements; and
- Prepare a Concern Response Report to address and respond to concerns.

In addition to the web forms submitted via the PEPC system, the NPS also received letters, electronic mail messages (emails), and faxes. The NPS entered these additional types of correspondence into the PEPC system, including the author information, type/date of correspondence, and the text. These correspondences were analyzed and addressed in the same manner as the correspondences submitted via PEPC.

Correspondences were evaluated to gain an understanding of topics raised by the public. Commonly occurring topics, topics discussed during internal NPS scoping, and topics from past planning documents were used to develop a draft coding structure. The framework for the coding structure was laid out and individual comments were pulled from each correspondence to be coded. Each comment received a unique identification number assigned by the PEPC system.

The coding structure was designed so that each code summarized a single theme raised by commenters. This allowed for each comment to have one or more codes assigned to it to capture every idea raised in that comment. As new topics were introduced from incoming correspondence, new codes covering the additional issues were added to the draft coding structure. As a result, the coding structure was revised continuously throughout the public comment process to ensure that all comments were included and coded appropriately.

Each code was classified as substantive or non-substantive according to criteria from the Director's Order (DO-) 12 Handbook (USDI, NPS 2001, 2009a). Substantive comments were defined as those that (1) question, with reasonable basis, the accuracy of information in the EIS, (2) question, with reasonable basis, the accuracy of the environmental analysis, (3) develop and evaluate reasonable alternatives other than those presented in the planning document, and (4) cause changes or revisions to the proposal or alternatives. In other words, substantive comments raise, debate, or question a point of fact or policy. Comments in favor of or against the proposed action or alternatives, or comments that only agree or disagree with NPS policy, are not considered substantive. Non-substantive comments do not require responses by the NPS.

Once the comment period had ended and all correspondences were reviewed, the coding structure was finalized and each comment was assigned a code or codes from those listed in Table B1. As comments were coded, any comments that helped illustrate a common concern raised by the public were selected as representative quotes. Additionally, comments that questioned or contested specific scientific information in the DEIS, introduced new, relevant scientific information, or contested the legality of the DEIS were pulled as representative quotes for NPS reference.

Following coding, all comments were analyzed by code to categorize issues and topics of concern raised by the public. Topics raised frequently in substantive comments were then used to create concern statements. In total, 3,938 substantive comments were coded and 43 concern statements were developed. Responses to the concern statements were composed. Reading, coding, and analyzing comments aided the NPS in determining if substantive issues brought forth by the public necessitated revisions to the analysis of the alternatives and impacts. Additionally, analyzing comments assisted the NPS in recognizing areas or text that needed clarification or correction prior to inclusion in the FEIS.

Summary of Correspondence

Correspondence received during the public comment period included letters, electronic mail (email), faxes, comments from public meetings, park forms, web forms submitted via the PEPC website, and other sources. The NPS received a total of 1,670 signatures on 1,644 correspondences, which were distilled into 5,773 individual comments.

Of these correspondences, there were nine master form letters, five of which were composed of sections of a larger master form letter (#246). A total of 433 correspondences contained text from the master form letters. The distributions of correspondence received are expressed in Table B1.

The topics that received the largest number of comments were (in order of most abundant) vaccine effectiveness, overall opposition to the proposed plan, keeping bison wild by leaving them alone, cattle industry concerns for tolerating bison outside the National Park, vaccine safety for bison, and cost of the program. The vaccine effectiveness comments addressed the effectiveness of either the vaccine or the proposed delivery method.

Table B1. Summary of comments received by public review.

Description	Number of Comments*	Number of Unique Comments
Alternatives: General comments	330	135
Alternative A: No action (support or opposition)	371	174
Alternatives: New alternatives outside agency authority and scope of this analysis	752	420
Alternatives: New alternatives that meet purpose and need statements and directives of IBMP	14	14
Cattle Considerations (transmission of brucellosis to cattle from bison)	220	202
Cost/Public Funds: General comments	22	21
Cost/Public Funds: Oppose use of public funds for this project ("costs too much")	1,341	801
Cost/Public Funds: Support use of public funds for this project	0	0

Description	Number of Comments*	Number of Unique Comments
Human Health and Safety (park staff and visitor safety)	52	42
Outside Scope: General comments	72	68
Overall Support of Proposed Action	51	46
Elimination/Eradication of Brucellosis	52	32
Eliminate Cattle from Area in or Around Yellowstone National Park/Separate Private Interests from Public Lands	558	209
Original IBMP and EIS are Flawed; ROD Should be Amended (opposed to other aspects of the IBMP)	70	38
Montana Department of Livestock Should Be Kept Out of Yellowstone	6	6
Alternative Grazing Areas for Cattle	54	14
Temporal and Spatial Separation Between Livestock and Bison; Grazing Area Separation; Fencing	184	124
Politics/Government Involvement	96	96
Cattle Industry Should Bear Costs/Vaccinate Cattle, Not Bison	279	229
Overall Opposition to Proposed Action	1,647	1,070
Purpose and Need: Compatibility of remote vaccination program with NPS mission statement, and/or policies	171	114
Purpose and Need: Appropriateness of vaccinating bison in a National Park/appropriateness of management	561	311
Scientific Evidence (adequacy of scientific evidence regarding the vaccine; contesting scientific evidence in the DEIS; presenting new scientific evidence)	922	572
Vaccine: Safety of bison	1,504	713
Vaccine: Effectiveness	2,500	982
Vaccine: Other vaccines considered	6	6
Vaccine: Booster vaccination	6	6
Visitor Use and Experience (don't want to see tagged/marked bison)	320	124
Other Wildlife (safety of other wildlife, proposed action does not address transmission of brucellosis by other wildlife)	177	135
Yellowstone Bison Population: General comments related to brucellosis prevalence	434	221
Yellowstone Bison Population: General comments unrelated to brucellosis prevalence or infection	80	35
Yellowstone Bison Population: Keep bison wild/leave them alone/American icons/against hazing (domestication of America's last wild bison, turning them into zoo animals)	1,632	897
Yellowstone Bison Population: Immunity to brucellosis generated by exposure to field strain	146	96

Description	Number of Comments*	Number of Unique Comments
Yellowstone Bison Population: Levels of tolerance for bison outside of park/cattle industry concerns	1519	657
Yellowstone Bison Population: Bison should take precedence on federal land	59	57
Yellowstone Bison Population: Size of range available for grazing	183	159
Yellowstone Bison Population: Native American considerations	138	69
Yellowstone Bison Population: Safety/general welfare of bison	691	515
Total Use of codes**	17,220	9,410
Total # of comments	9,795	5,777

*Comments include those repeated in multiple correspondences, such as form letters. Unique comments exclude repeats.
**The use of codes exceeds the number of comments because a single comment can be associated with multiple codes.

Support for Alternatives

The DEIS evaluated the use of three alternatives, including Alternative A (no action), Alternative B (addition of remote vaccination of calves and yearlings), and Alternative C (addition of remote vaccination of all ages). Alternative A garnered support from several groups, including 189 copies of a form letter from the Natural Resources Defense Council and its members. Alternative B received the least support of any alternative. Alternative C received the support of several large groups, but few unaffiliated individuals submitting comments. The Buffalo Field Campaign proposed an additional alternative and 94 form letters were received supporting this alternative.

Correspondence by Type of Author

Conservation and preservation groups provided the greatest diversity and number of comments. Since commenters self-categorize themselves, there is a possibility that the information was input incorrectly—especially if respondents quickly began inserting comments without completely entering their background information. Correspondences were received from 1,619 unaffiliated individuals.

County Government
Beaverhead County Commissioners – Correspondence #858
Park County Commissioners – Correspondence #788
Phillips County Commissioners – Correspondence #934
Phillips County Board of Commissioners – Correspondence #935

Federal Government

USDA, Animal & Plant Health Inspection Service, Veterinary Services, Western Region – Correspondence #1544
U.S. Environmental Protection Agency – Correspondence #888

Recreational Groups
Orion The Hunters Institute – Correspondence #787
On Shore Foundation Inc. – Correspondence #1017

Non-Governmental Organizations
National Assembly of State Animal Health Officials – Correspondence #1403
Phillips County Livestock Association – Correspondence #936
Wyoming Farm Bureau – Correspondence #1639

Civic Groups
Animal Welfare Institute – Correspondence #1643

Conservation / Preservation
Buffalo Field Campaign – Correspondence #859
Gallatin Wildlife Association – Correspondence #890
Greater Yellowstone Coalition – Correspondence #1026 and1645
National Humane Education Society – Correspondence #1590
National Parks Conservation Association – Correspondence #1620
National Wildlife Federation – Correspondence #1579
Natural Resource Defense Council – Correspondence #1644
Yellowstone Buffalo Foundation – Correspondence #899

Tribal Government
Sisseton-Wahpeton Oyate – Correspondence #789

State Government
Economic Affairs Interim Committee/Montana – Correspondence #929
Montana Department of Livestock – Correspondence # 751
Montana Fish, Wildlife & Parks – Correspondence #1614

Concerns Provided by Respondents and Responses from the NPS

Alternatives: General Comments

CONCERN: Alternative C will neither allow Yellowstone's bison to roam more freely nor significantly decrease the risk of disease transmission to cattle. Careful consideration of alternative brucellosis control measures is warranted.

Quote(s): Comment ID: 152824 Organization Type: Unaffiliated Individual
Representative Quote: “Either of the proposed remote vaccination programs (Alternatives B and C) would be ineffective and costly, wasting millions of taxpayer dollars without increasing tolerance for buffalo in Montana one of the central goals of the IBMP.”
Comment ID: 152877 Organization: United States Animal Health

Association (USAHA)
Representative Quote: "The DEIS neglects to address immunocontraception (IMCT) of seropositive bison. This technology has been implemented in other wild animal populations and has shown promise in bison. While USAHA supports vaccination of bison with RB51, and understands that NPS is limiting the scope of this DEIS to vaccination with RB51, the technology of IMCT has the potential to mitigate numerous "negative impacts" described in the DEIS. IMCT would reduce negative impacts on NPS employees by limiting administration of biologicals to the controlled environment of the capture facility. Additionally, IMCT: a) Stops transmission of the *Brucella abortus* within one reproductive cycle by preventing reproduction of seropositive bison; b) Is efficacious for several years with one dose; and c) Moderates the growth of the bison population while the prevalence of brucellosis is being actively reduced."
Comment ID: 162643 Organization: Animal Welfare Institute
Representative Quote: "The termination of the packing of winter snow roads would also help reduce the seroprevalence of the populations. As the NPS indicates in the DEIS, the *Brucella abortus* bacteria is at greater risk of being transmitted to another species during the second and third trimesters of pregnancy (from approximately January to June). While there is virtually no risk of bacteria transmission to cattle at that time due to the fact that most cattle have been removed from the area due to climatic and snow conditions, an abortion event could still cause intraspecific transmission between bison and interspecific transmission between bison and elk. The risk of such a transmission occurring is, in part, dependent on the size of the bison group or herd. The larger the herd in the vicinity of the aborted fetus the greater the chance of exposure through exploratory behavior until the carcass is scavenged by predators/carnivores. The NPS concedes, however, that during winter bison herds tend to break up into smaller groups compared to other times of the year to survive the harsh winter environment thereby reducing the potential number of transmission events as a result of a single abortion. Packed snow roads, however, allow bison to maintain their social bonds and to maintain larger groups who can travel together across the winter landscape using, in part, packed snow roads as energy efficient travel routes. It follows then that if the packed roads were not available, bison groups would have to break up into smaller units (depending on winter severity) to survive. The smaller the number of bison in a particular group, the lower the potential for a transmission event and/or the lower the number of transmission events in the unlikely occurrence of a *Brucella*-induced abortion."

Response: The NPS agrees that implementing an operational program of remote vaccination for bison is unlikely to significantly change the already low risk of brucellosis transmission from bison to cattle. Thus, NPS suspects that an increase in tolerance for bison outside the park will not occur due to remote vaccination of bison in the park. Comments received on the DEIS indicate livestock groups will be more tolerant of free-ranging bison outside Yellowstone National Park once a bison vaccination program is initiated. While, analyses included in the FEIS suggest vaccination could result in a reduction in brucellosis prevalence over time, the amount reduction in brucellosis infection sustained by the Yellowstone bison is not worth the effort and cost to implement a program. Thus, the NPS recommends continued development and reassessment when better vaccine and delivery methods are available.

The NPS agrees that careful consideration of alternate measures to decrease the risk of brucellosis transmission from wildlife to cattle is warranted. The impacts of immunocontraception were not evaluated in this FEIS because it was outside the scope of the analysis. Also, at this time, there is little data to apply this concept in a disease management framework (Rhyan and Drew 2002). The Animal and Plant Health Inspection Service is currently conducting an experimental study of immunocontraception of bison in Corwin Springs, Montana.

After considering environmental concerns and findings, including the use of groomed roads by bison, the NPS developed a Supplemental EIS, ROD, and long-term regulation during 2013 that will continue the grooming of interior park roads for over-snow vehicles. Gates et al. (2005) noted that closing roads to oversnow vehicles will not prevent bison from leaving the park.

CONCERN: All alternatives leave an unacceptably high seroprevalence rate after 30 years of implementation.

Quote(s): Comment ID: 153699 Organization: Wyoming Livestock Board
Representative Quote: “It is important to note that all Alternatives leave an unacceptable high estimated seroprevalence rate as late as the year 2010 (16%).”

Response: Different constituency groups have different levels of acceptance for brucellosis prevalence in bison. The NPS considered a 50% decrease in seroprevalence acceptable because brucellosis eradication is not possible at this time due to limitations of vaccine efficacy, duration, delivery, diagnostics, and reinfection from elk. Additional explanation is included in the FEIS in Chapter 2, Section 2.2, and Appendix F.

Alternatives: New Alternatives Outside Agency Authority and Scope of this Analysis

CONCERN: Urge Yellowstone to reject all alternatives in its Draft Environmental Impact Statement, and develop an alternative to buy out cattle in the bison's range and to conserve the habitat in perpetuity for native wildlife: Wild Buffalo Trust Alternative D.

Quote(s): Comment ID: 150313 Organization Type: Unaffiliated Individual
Representative Quote: “I politely request that, since vaccinating wildlife is ineffective, costly, harmful, & culturally unacceptable, an

alternative to buyout cattle in Yellowstone, Madison, & Gallatin river valleys is implemented instead. This buyout should focus on connectivity of habitats & wildlife migration & funds could be used to erect wildlife proof fencing around cattle. Free range dispersal of buffalo where cattle no longer graze would allow buffalo access to forage to meet their nutritional needs & maintain healthy populations for future generations. The Wild Buffalo Trust Alternative D meets the Park's mandate ... from Congress to conserve & leave buffalo "unimpaired for the enjoyment of future generations." It also follows Park Management policies & directives requiring "protection of ecological processes & native species in a relatively undisturbed environment."

Response: This alternative is beyond the purpose, need, and objectives of this EIS. However, conservation groups and government agencies have previously engaged, and will continue to engage, with willing landowners to create conflict-free habitat for bison on key winter ranges in Montana, including the removal of cattle from some areas.

CONCERN: The NPS should develop an alternative that would minimize or eliminate vaccination of bison in favor of the mandatory vaccination of domestic livestock.

Quote(s): <u>Comment ID: 162642</u> Organization: Animal Welfare Institute
Representative Quote: “Under this alternative, the remote vaccination program would be removed from consideration at least temporarily. It would be replaced by a series of alternative management measures that would be entirely consistent with the goals of the IBMP (which ostensibly are to protect a free-ranging bison population in YNP [Yellowstone National Park] while also protecting Montana's cattle industry) and could also aid in reducing seroprevalence in the bison population.

Specific elements of these alternative management measures could include, but would not be limited to, the: termination of the winter packing of some or all snow roads in YNP in order to restore, to the extent possible, naturalness to the ecological functioning of YNP; closure of public grazing allotments near YNP to permanently remove cattle from public lands; transition of existing cow-calf grazing operations to alternative stock where the consequences of any exposure to *Brucella abortus* is inconsequential; payments to private landowners/hobby ranchers in exchange for their permanent removal of cattle from their lands; construction of fences (double fencing if deemed necessary) to confine remaining cattle herds while allowing greater freedom for emigrating bison; U.S. Forest Service management of a viable population of bison on its lands surrounding YNP; imposition of a mandatory cattle vaccination program in Montana; and potential application of immunocontraceptive agents to younger-aged bison to prevent births during the most likely time when the bison may be infectious. Considering the estimated costs of the remote vaccination program, which the NPS likely underestimates at $9 million dollars over 30 years, DEIS at 21, this would represent an ample sum of funds to initiate such alternative efforts."

Response: Not implementing the remote vaccination program would be consistent with Alternative A (No Action). Some of the management measures mentioned above are included in the adaptive management plan for the IBMP, such as construction of fencing and buying of conservation easements to reduce or eliminate cattle conflicts within the bison conservation area (U.S. Department of Interior 2008). Some aspects of the commenters proposed alternative is beyond the purpose, need, and objectives of this EIS , such as closure of public grazing allotments near Yellowstone National Park, directing the type of livestock operations on public allotments, U.S. Forest Service management of bison, etc.

CONCERN: Yellowstone National Park should broker a multi-agency discussion around eradication of brucellosis as opposed to containment of the disease.

Quote(s): Comment ID: 153235 Organization: Phillips County Livestock Association

Representative Quote: "We thus recommend that the NPS adopt the practices of sound disease control and eradication to achieve the goal of having a sound, healthy robust herd of bison which the entire nation could be proud of dwelling in Yellowstone National Park, The Crown Jewel Park of the NPS system."

Response: Eradication of brucellosis from the greater Yellowstone ecosystem is beyond the purpose, need, and objectives of this EIS. Cheville et al. (1998:122) noted that the elimination of brucellosis from bison is not feasible at this time due to limitations of vaccine efficacy, duration, delivery, diagnostics, and reinfection from elk.

Alternatives: New Alternatives that Meet Purpose and Need Statements and Directives of IBMP

CONCERN: Instead of implementing Alternative C full-scale, permit a small pilot project, using the methods proposed, to be initiated to determine if there's even any reason to proceed with a full-scale project.

Quote(s): Comment ID: 162658 Organization: Animal Welfare Institute

Representative Quote: "This alternative would permit a small pilot project, using existing technologies, to be initiated to determine if there's even any reason to proceed with a full-scale project. If, for example, it is determined that park biologists can't routinely approach bison within the requisite distance to effectively deliver a biobullet, if it proves to be too difficult, time consuming, or costly to treat anywhere near the desired number of bison, and/or if it is determined that shot placement is not sufficiently accurate to avoid causing injuries (other than insignificant penetration entry wounds) or mortality of vaccinated bison, this would be compelling justification to terminate any plan to broaden the use of remote vaccination. These are not speculative problems that AWI has concocted to try to undermine the remote vaccination program rather, as reported by Quist and Nettles (2003) and Roffe et al. (2002), these are real potential implications of the vaccination program using existing technologies."

Comment ID: 162638 Organization: Animal Welfare Institute

Representative Quote: "It does, however, assert that the NPS erred in not subjecting other alternatives to serious consideration in the DEIS. Such other alternatives could have included, but would certainly not be limited to: B) an alternative that would delay initiation of any remote vaccination program pending development of a new, more effective, vaccine and improved delivery technologies; and

C) an alternative that would initiate a small remote vaccination pilot project in YNP while research and other efforts continues to address the many unanswered questions and better understand the direct, indirect, and cumulative impacts of the action alternatives as described in the DEIS."

Comment ID: 162645 Organization: Animal Welfare Institute

Representative Quote: "This alternative wouldn't terminate a planned remote vaccination program but it would delay implementation of such a program pending the development and testing of a new, more efficacious vaccine and an improved delivery system. Admittedly, if this proposed alternative were to be selected, it would terminate the current planning process as a new DEIS would be required to evaluate the new vaccine and improved delivery system. Many portions of the DEIS would remain exactly the same avoiding any need for the NPS to restart the planning process from square one.

Considering the many unanswered questions relevant to the proposed remote vaccination program (questions that are identified in the DEIS, in some of the cited documents, and some of which are identified below) and the fact that the current ballistic delivery system is not, by any stretch of the imagination, ideal or acceptable, this alternative is warranted as it buys time for the scientific community in the United States and in other countries to potentially develop and test new vaccines and invent more effective and creative delivery systems that may answer some of the questions and/or address some of the problems inherent to the proposal on the table. Admittedly, this alternative would not satisfy all interests - particularly those who entirely oppose any vaccination of YNP bison for a number of completely valid reasons - though it could, if or when a new vaccine and deliver system is developed - result in a remote vaccination program that is more certain in its effects and impacts than the present proposal."

Response: There is much uncertainty in available vaccines, delivery tools, and diagnostics (Appendix F). Additional uncertainty exists in how bison will react to remote delivery methods and how tolerance in the State of Montana may change in response to bison being vaccinated against brucellosis. The NPS has further clarified the description of alternatives in the FEIS to include an adaptive management process that incorporates monitoring and research to answer uncertainties, make improvements, and attain reasonable assurances of success before implementing costly, long-term, remote vaccination of bison park-wide. The NPS, in selecting the no action alternative, is committed to advancing the science of brucellosis risk management and reconsidering remote delivery as new technologies become available. The NPS is not willing to implement an operational remote vaccination program at this time and would need to see advances that facilitate effective outcomes, minimize adverse impacts to bison, and lower operational costs. However, under adaptive management, the NPS could conduct research (including pilot studies) to evaluate new developments in vaccines, delivery, diagnostics, etc.

CONCERN: Consider additional strategies that provide a greater probability to reduce brucellosis infection, shedding, and population prevalence through the combined effects of multiple approaches to brucellosis reduction (such as immunocontraception).

Quote(s): Comment ID: 152901 Organization: United States Animal Health Association

Representative Quote: "Comments on All Proposed Alternatives: The DEIS neglects to address immunocontraception (IMCT) of seropositive bison. This technology has been implemented in other wild animal populations and has shown promise in bison. While USAHA supports vaccination of bison with RB51, and understands that NPS is limiting the scope of this DEIS to vaccination with RB51, the technology of IMCT has the potential to mitigate numerous "negative impacts" described in the DEIS. IMCT would reduce negative impacts on NPS employees by limiting administration of biologicals to the controlled environment of the capture facility. Additionally, IMCT: a) Stops transmission of the *Brucella abortus* within one reproductive cycle by preventing reproduction of seropositive bison; b) Is efficacious for several years with one dose; and c) Moderates the growth of the bison population while the prevalence of brucellosis is being actively reduced."

Comment ID: 164225 Organization: Animal Welfare Institute

Representative Quote: "If an immunocontraception option were implemented, pending appropriate environmental review of course, it could prevent the younger-aged bison from conceiving and giving birth. Since, as the scientific data indicates, younger-aged bison are more likely than other bison to be infectious and, therefore, theoretically capable of transmitting the bacteria and considering that the route of transmission is through contact with a contaminated aborted fetus, live calf, or reproductive materials, preventing these younger animals from breeding would reduce the risk of intraspecific and interspecific disease transmission and, in time, should reduce overall seroprevalence in the YNP bison populations."

Response: Immunocontraception of bison is currently being studied by the Animal and Plant Health Inspection Service. Implementation is beyond the scope of this FEIS which considers whether to initiate remote vaccination of bison inside Yellowstone National Park. While some commentors suggested that immunocontraception may be effective at preventing shedding during the time period of life when shedding of *Brucella* bacteria is most likely, no details were provided to share new information that NPS did not consider. Fertility control products have several potential individual and population-level side effects, such as extended breeding seasons, changes in life span, reduced genetic diversity, and alterations in social behavior and organization that should be considered prior to any management intervention (Gray and Cameron 2010). There have been little to no studies of these possible side effects in bison. For now, these concerns and the intrusive human intervention required to implement sterilization or contraception limit the NPS's discretion and/or willingness to employ them with Yellowstone bison (NPS Organic Act of 1916 and General Authorities Act of 1970; NPS 2006).

Cost/Public Funds: Oppose Use of Public Funds for this Project (Costs Too Much)

CONCERN: Vaccinating wild bison is a waste of millions of dollars of taxpayers' money.

Quote(s): Comment ID: 152922 Organization Type: Unaffiliated Individual
Representative Quote: "Either of the proposed remote vaccination programs (Alternatives B and C) would be ineffective and costly, wasting millions of taxpayer dollars without increasing tolerance for buffalo in Montana which is one of the central goals of the Interagency Bison Management Plan."
Comment ID: 155712 Organization Type: Unaffiliated Individual
Representative Quote: "Given the current fiscal situation of the country, I feel this is an especially irresponsible waste of tax money. I do not want my taxes going to fund such a program."

Response: The conservation and management of wild, free-ranging bison is costly and includes measures to minimize the probability of brucellosis transmission to nearby cattle to accommodate concerns of the State of Montana (USDI and USDA 2000a,b). The NPS will use adaptive management measures as they become available to minimize costs and improve operational efficiency and conservation values."

Human Health and Safety (Park Staff and Visitor Safety)

CONCERN: Park visitors may come into contact with biobullets or hunters may consume bison meat from a vaccinated bison and might get sick.

Quote(s): Comment ID: 162562 Organization: Buffalo Field Campaign
Representative Quote: "Evaluate and disclose how immobilizing/ reviving bison with drugs, and SRB51 vaccination, will affect hunters. Will drugs persist in tissues? Will the vaccine persist in blood? Why didn't the Park survey bison hunters or hunters who have submitted

for tags? SRB51 may persist for over 120 days (Protection of *Brucella abortus* RB51 revaccinated cows, introduced in a herd with active Brucellosis, with presence of atypical humoral response, Comparative Immunology, Microbiology and infectious Diseases, January 2005, Volume 28, Issue 1, Pages 63-70). How will SRB51 vaccine persistence affect hunters?"

Comment ID: 153435 Organization: U.S. Environmental Protection Agency (EPA)

Representative Quote: "Included among EPA's comments are potential public health concerns regarding possible contact by human handlers or member of the public, including Park visitors, with live brucellosis vaccine. Brucellosis vaccines are characterized as modified live vaccines which have a greater risk of infection by human handlers if appropriate precautions are not taken, and 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 and the proposed Strain RB51 vaccine (SRB51) consists of a live culture of these disease causing microorganisms.

While the DEIS states that stringent handling protocols have been developed to address safety concerns and minimize risk to humans from handling *Brucella abortus* vaccine when implementing the vaccination program, we believe that potential risks to members of the public visiting the Park, other animals besides bison and the environment should be more clearly disclosed. We note that the DEIS states that remote delivery system using compressed air powered rifles and biobullets containing live vaccine is not designed for high accuracy and long distances like conventional rifles. Consequently, we assume some biobullets may miss their target and be disseminated into the environment where they could come into contact with other animals or the public."

Comment ID: 161149 Organization: Gallatin Wildlife Association

Representative Quote: "Furthermore, there is at least a 21 day time period after vaccination SRB51 that the DEIS specifies that hunters should not consume any of the meat (DEIS page 107). How were these time frames determined? What level of uncertainty is associated with these time frames? Were these time frames determined on vaccinated wild bison in a remote setting in the GYA? Work done by Leal-Hernandez et al. (2005) indicates RB51 vaccine strain was isolated from milk and vaginal exudates from two cows after delivery at day 120 post-revaccination. We question the recommendations for meat consumption made in the DEIS to be overly optimistic. This paper also questions the dogma that RB51 vaccination does not induce antibodies that interfere with Brucellosis diagnosis and thus surveillance plans. We are very concerned how bison vaccinations that take place during or just prior to potential hunting seasons may disrupt hunting opportunity now and into the future."

Response: 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. The agency 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.

For decades hunters in Montana have harvested and consumed bison and elk, some of which were almost certainly infected with field strain *Brucella abortus*. The NPS acknowledges that risk to hunters from harvesting vaccinated bison within the 21-day withdrawal period timeframe is a concern, and has not released vaccinated bison from captivity during the hunting season. The logistics of managing hunts of bison that migrate outside the park in concert with implementing a remote vaccination program requires close coordination between the NPS, Montana Fish, Wildlife & Parks, and American Indian tribes with treaty hunting rights in southwestern Montana and was a factor in selecting the no action alternative.

Purpose and Need: Compatibility of Remote Vaccination Program with NPS mission Statement, and/or Policies

CONCERN: The current DEIS does not satisfy the requirements of the National Environmental Policy Act (NEPA). The plan put forward under the DEIS conflicts with laws and statutes, such as the Organic Act, and the original Lacey Act.

Quote(s): Comment ID: 162601 Organization: Animal Welfare Institute
Representative Quote: "... unless the NPS can demonstrate that the proposed remote delivery vaccination program will not result in wounds to the target or non-target animals, the program cannot be legally implemented in YNP."

Comment ID: 162600 Organization: Animal Welfare Institute
Representative Quote: "In 1894 Congress provided additional protection to wildlife within the park, largely in response to continued poaching of bison. In what is often referred to as the original Lacey Act, Congress prohibited within the boundaries of the park "[a]ll hunting, or the killing, wounding, or capturing at any time of any bird or wild animal, except dangerous animals, when it is necessary to prevent them from destroying human life or inflicting an injury." "... What is of particular interest in this language that is directly relevant to the proposed remote delivery vaccination program is the prohibition on wounding any bird or wild animals within YNP. Thus, if the proposed remote delivery vaccination program will result in the wounding of bison in YNP - as it surely will as conceded by the NPS, demonstrated by Quist and Nettles (2003), and discussed in this letter - then it would be illegal under this law and, accordingly, can't be allowed."

Comment ID: 162858 Organization: Animal Welfare Institute
Representative Quote: "In summary, as determined by the courts in Bluewater, Sierra Club, and Greater Yellowstone Coalition, the NPS, when making impairment determination must employ meaningful and objective standards and provide a rational explanation as to how the facts allow the NPS to make an impairment finding. Indeterminate and conclusory statements used to make impairment findings are, based on case law, clearly impermissible. Unfortunately, the environmental consequences section in the DEIS and the NPS impairment findings suffer from the same deficiencies as found in those NEPA documents ruled illegal by the courts in Bluewater, Sierra Club, and Greater Yellowstone Coalition."

Comment ID: 162585 Organization: Animal Welfare Institute
Representative Quote: "The current DEIS does not satisfy the requirements of the National Environmental Policy Act (NEPA). It does not provide a legitimate purpose and need statement. It does not consider a range of reasonable alternatives. And, it does not disclose nearly enough "high quality" information or subject it to "accurate scientific analysis" thereby compromising its evaluation of the environmental impacts of the alternatives and preventing the public from understanding and providing substantive comments on the document. Moreover, though the NPS cites to a broad range of studies, published and unpublished, documents, and other evidence to ostensibly support its claims, it fails to disclose, adequately summarize, or analyze the content of those studies/documents in the DEIS."

Comment ID: 162113 Organization: Natural Resource Defense Council
Representative Quote: "The National Park Service Organic Act unequivocally states that the National Park Service's "purpose is to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for their enjoyment and leave them unimpaired for future generations." 16 U.S.C. § 1. Because of the long- term risks associated with it, a remote vaccination program contravenes the park Service's mission under the Organic Act."

Response: The purpose of this action (section 1.3, FEIS) is to address NPS responsibilities as directed by the IBMP in the 2000 ROD. Specifically this analysis is to address the feasibility of remote vaccination that was conceived, but not fully analyzed, in the 2000 FEIS. The need for a vaccination program is to decrease abortion events and reduce brucellosis transmission among Yellowstone bison in a manner that advances conservation of the population. Vaccination in that analysis was intended to address three objectives: commit to the elimination of brucellosis in bison; protect livestock from risk of brucellosis transmission from wildlife; and be based on factual information recognizing that the database for assessment is changing. This FEIS is responsive to this purpose and those needs and discloses a large and complex analysis of feasibility based on facts that were not available in 2000. The DEIS includes an extensive list of citations (over 250) upon which the analysis was based. NEPA analyses do not require that agencies provide an extensive review of each citation.

Concerns regarding the wounding of bison from the delivery of the vaccine were important in the analysis of this EIS. The wounding of bison to deliver the vaccine is not considered inconsequential, but was analyzed (sections 4.2 and 4.6, FEIS) and considered to be a short term, minor, adverse effect. As further clarified in the FEIS, the actions proposed in this EIS would not have greater than negligible, short-term adverse impacts to wilderness character within the park (Chapter 1, FEIS). All of the data that was used to justify selecting the no action alternative considered the tradeoff between negligible to minor effects of wounding against the possibility of decreasing brucellosis transmission and gaining more tolerance for wild bison outside Yellowstone National Park. Further research and continued assessment of available vaccines and delivery methods is proposed as research needed to further the science of brucellosis risk management and reduce brucellosis infection in Yellowstone bison. The adaptive management strategy (described in Chapter 2) identifies additional work that needs to be conducted before an operational park-wide vaccination program should be reconsidered.

Pursuant to guidance from the Intermountain Regional Director (A56 [IMDE-OEQ]) in November 2011, a non-impairment determination should be prepared only for the selected alternative, and that determination should be appended to the decision document (ROD) and not included as an appendix or otherwise in the EIS. The preferred alternative for the vaccination of Yellowstone bison is Alternative A (No Action). A written determination regarding impairment and unacceptable impacts will be made for each of the impact topics carried forward for detailed analysis in the EIS and appended to the ROD signed by the Regional Director. Pursuant to the *Guidance for Non-Impairment Determinations and the NPS NEPA Process* (2011), impairment findings are not necessary for visitor experience, socioeconomics, public health and safety, environmental justice, land use, or park operations because these impact topics are not generally considered to be park resources or values, and are therefore not subject to the written impairment determination requirement found in the NPS *Management Policies* 2006. A description of the current state of each of the resource topics evaluated for impairment can be found in Chapter 3 of the EIS (Affected Environment).

CONCERN: Vaccinating Yellowstone bison is an intrusive action that is not justified by NPS policy relative to minimizing human impacts to biological resources (native plants and animals, populations, ecosystems and natural processes that sustain native plants and animals).

Quote(s): <u>Comment ID: 159709</u> Organization: Greater Yellowstone Coalition
Representative Quote: “NPS is obligated under its 2001 management

policies to manage and preserve natural ecosystems and the native animals and plants that they sustain. In achieving this goal, NPS is charged with "minimizing human impacts on native plants, animals, populations, communities, and ecosystems, and the processes that sustain them" (NPS Policies, 4.4.1). Vaccinating Yellowstone bison is intrusive and of questionable merit at this time and therefore cannot be justified in accordance with NPS policy and legal mandates."

Comment ID: 153782 Organization Type: Unaffiliated Individual
Representative Quote: "NPS 6.3.5 details the concept of the "minimum requirement." "All management decisions affecting wilderness must be consistent with the minimum requirement concept." This obliges the NPS to determine first "whether the proposed management action is appropriate or necessary for administration of the area AS WILDERNESS and does not cause a significant impact to wilderness resources AND CHARACTER" (emphases added). The DEIS has not done so. And it clearly must."

Comment ID: 153784 Organization Type: Unaffiliated Individual
Representative Quote: "Where the DEIS most directly contradicts NPS 6.3.7 is in the statement "Control of invasive alien species [in the case *Brucella abortus*] . . . should be attempted only when the knowledge and tools exist to accomplish clearly articulated goals." The DEIS repeated emphasizes that this knowledge does not exist. For example, page 17: "The effectiveness of [the chosen] vaccine against field strain *Brucella abortus* is not conclusive and mixed results have been reported by various research projects." On page 108, the DEIS states that "from 1985 to 2002, over 53,000 doses of *Brucella abortus* vaccine were delivered to elk" in Wyoming. All that vaccine, and elk still transmitted brucellosis to cattle in Wyoming. Isn't it clear that the "knowledge and tools" do not exist to accomplish the stated goals? This appears to be less Adaptive Management, and more experimentation."

Comment ID: 162608 Organization: Animal Welfare Institute
Representative Quote: "NPS Policies distinguish between exotic species whose management is high priority versus those of low priority. High priority is reserved for exotic species that have, or potentially could have, a substantial impact on park resources and that can reasonably be expected to be successfully controlled. NPS Policies at 4.4.4.2. A lower priority will be assigned to "exotic species that have almost no impact on park resources or that probably cannot be successfully controlled." Id. Based on current and past *Brucella abortus* and bison models and given the limitation of existing technologies (even with the implementation of a remote delivery vaccination program), it is clear that *Brucella abortus* in YNP should be designated as a lower priority species since it has "almost no impact on park resources."

Response: The intrusiveness of implementing a vaccination program is a value judgment made by many commenters. The inclusion of vaccination as a tool for managing Yellowstone bison was considered in the 2000 FEIS for the IBMP and a policy review was completed before the

Secretary of the Interior signed the ROD. Vaccination is a disease management tool that warrants consideration in brucellosis reduction programs. The challenge in implementing a vaccination program in wildlife is effectively delivering effective doses of vaccine to enough animals to induce the desired decrease in infection rate, while doing so in a manner that does not significantly alter their behavior and limits the handling of animals. By selecting the no action alternative, the NPS has addressed all of the concerns raised in the above statements.

As further clarified in Chapter 1 of the FEIS, there are no Congressionally designated wilderness areas within the park. However, portions of the park are recommended for wilderness designation. None of the actions proposed in this EIS would have greater than negligible, short-term adverse impacts to wilderness character within the park. Thus, further analyses are not necessary.

Purpose and Need: Appropriateness of Vaccinating Bison in a National Park/Appropriateness of Management

CONCERN: America's first national park, which belongs to all Americans, should not be used as a testing ground to shoot the nation's last genetically unaltered bison herd with a questionable vaccine.

Quote(s): Comment ID: 159707 Organization: Greater Yellowstone Coalition
Representative Quote: "In practice, the remote vaccination proposal appears to be primarily an experimental program conducted on a large scale across Yellowstone National Park with major uncertainties that will only be revealed by field experience. This approach to large scale experimentation on Yellowstone's bison herd is an inappropriate activity for bison management in Yellowstone. The proposal is plagued with uncertainties - uncertain effectiveness, uncertain pathogenicity, uncertain reaction by bison and/or modification of bison behavior from remote vaccination, and many others. As the DEIS makes clear, answers to these questions are required before the remote vaccination program proceeds, but we do not believe that experimentation on the bison herd inside Yellowstone National Park is the appropriate way forward."

Response: Vaccination is a disease management practice that is included in many wildlife management programs around the world for a variety of diseases in many different species of wildlife (section 1.1, FEIS). The vaccine SRB51 has been tested in numerous experiments and evidence demonstrates that many vaccinated bison exhibit some level of immune response that reduces the probability of aborting pregnancies and shedding *Brucella abortus* bacteria following exposure to the bacteria. Given existing conditions and technologies, however, it is uncertain whether a vaccination program could be effectively implemented for Yellowstone bison to reach a high level of population immunity (resistance) to brucellosis infection and transmission (see Appendix F). Consequently, the NPS has identified the no action alternative as the preferred alternative with an emphasis on adaptive management to learn more about the opportunities and necessity of a park-wide vaccination program for bison. Additional research and monitoring would be necessary to develop technologies and techniques to effectively suppress brucellosis in Yellowstone bison. Some of this research may occur in Yellowstone National Park, as described under the adaptive management section in Chapter 2.

CONCERN: Active management is consistent with responsible stewardship of wildlife.

Quote(s): Comment ID: 153700 Organization: Wyoming Livestock Board (WLSB)

Representative Quote: “However, the WLSB applauds NPS for the DEIS that acknowledges that active management is consistent with responsible stewardship of wildlife species.”

Response: NPS policy provides guidance to work diligently with partners to resolve boundary conflicts by implementing solutions that do not impair park resources. Management Policies (2006) section 8.11.2 state that the NPS will use the best available science to assist park managers in addressing management needs and objectives that have been identified in legislation and planning documents. In addition, the NPS will support studies to provide a sound basis for policy, planning, and decision-making; develop effective strategies, methods, and technologies to predict, avoid, or minimize unacceptable impacts on resources.

Scientific Evidence (Adequacy of Scientific Evidence Regarding the Vaccine; Contesting Scientific Evidence in the DEIS; Presenting New Scientific Evidence)

CONCERN: The data supporting the implementation of a remote vaccination program are contentious.

Quote(s): Comment ID: 162688 Organization: Animal Welfare Institute

Representative Quote: “Indeed, the NPS concedes in the DEIS that: 1) "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 difference in diameter of the delivery tools and location of delivery within muscle tissue," DEIS at 88; 2) "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," id.; and 3) "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)." DEIS at 88/89.

Despite these statements, the NPS largely dismisses the serious implications of the remote vaccination program resulting in wounds, injuries, serious injuries, permanent disability, or even the mortality of treated bison. It reports, for example, that "while wounds resulting from remote delivery methods that 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." DEIS at 88. This may be true but Morgan et al.'s experiment involved domestic cattle, not wild, free ranging bison. As a consequence, it is far more likely that delivery of the bio-degradable projectiles were more accurately placed in the domestic cattle than they would be in wild bison (since cattle are routinely handled by humans, bred for docility, frequently fed by humans, and therefore have little fear of humans). It is also possible, if not likely, that the cows in their experiment may have been treated with antibiotics during their lives, including potentially during the experiment, that would have helped ward off any potential infection caused by the projectile. Of course, wild bison remotely vaccinated would not be concurrently provided with an antibiotic to help prevent any infection."

Response: Concerns regarding the wounding of bison from the delivery of the vaccine were important in the analysis of this EIS. The wounding of bison to deliver the vaccine is not considered inconsequential, but was analyzed (sections 4.2 and 4.6, FEIS) and considered to be a short term, minor, adverse effect. As necessary, further research on delivery methods and wounding or other unintended effects could be conducted under the adaptive management strategy described in Chapter 2.

CONCERN: The effectiveness and side effects of the vaccine and delivery system are unknown due to insufficient data.

Quote(s): Comment ID: 162854 Organization: Animal Welfare Institute
Representative Quote: "To complicate matters, the NPS does concede that the efficacy of the vaccine may be compromised due to factors that related to environmental conditions and the physical condition of YNP bison. Specifically, the NPS reports that: "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 late challenged by natural exposure to *Brucella 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 antibodies which will combat the foreign substance)." DEIS at 74

While it is entirely appropriate that the NPS disclosed this information, there's no evidence that it was taken into consideration in the NPS analysis of the efficacy of the vaccine in the field and the myriad factors that may reduce said efficacy. While AWI understands the NPS's interest in putting its best argument forward to promote the proposed remote vaccination program, NEPA requires the agency to disclose and consider all relevant information, positive or negative, that, in this case, would affect the efficacy of the vaccine. Since vaccine efficacy is, to be frank, the primary factor that must be considered in determining whether the proposed remote delivery vaccination program should be implemented and to estimate its potential impacts, full and fair disclosure and analysis of all information relevant to vaccine efficacy should have been made available in the DEIS.

Furthermore, the NPS does not provide an adequate explanation as to whether RB51 constitutes a "highly efficient vaccine" the use of which could ostensibly overcome some of these complications or how or if its planned remote administration of the vaccine could realistically treat a sufficient proportion of the eligible bison population to avoid the potential problems cited above. Instead, the NPS claims that its surveillance program and adaptive management process will be used to mitigate potential adverse effects though it even fails to explain the specifics of how that will be accomplished. DEIS at 74."

Response: The effectiveness of SRB51 vaccine has been researched in clinical trials that provide enough data to justify use in an applied management program with wildlife. Eight separate clinical trials were conducted in Ames, Iowa and the results were generally consistent among trials. The NPS consulted with the research scientists that produced the vast majority of peer reviewed literature on brucellosis vaccine research in bison and elk, and their recommendation was to implement field vaccination trials to learn how effective vaccination could be in a wild land setting.

Subsequently, the NPS monitored and evaluated two groups of Yellowstone bison that were vaccinated with SRB51 in or near the park during late winter and determined that in both groups less than 50% of the bison exhibited a strong immune response (Treanor 2012). Vaccine protection requires the stimulation of immune system cells and organs such that any future exposure to similar stimuli will generate a response to more quickly recognize the antigen and fight back by activating specialized cells that destroy the *Brucella* invaders (Tizard 2004). Treanor (2012) noted that nutrition plays a key role in influencing how effective an immune response to brucellosis infection can be for vaccinated bison. Immune response to infection is done at the expense of stored energy and proteins. In Yellowstone bison, stored energy in the form of fat declines over the course of winter and is much reduced during late pregnancy when the *Brucella abortus* infection process is most active. Consequently, the vaccination of wild bison is less effective at preventing infection and likely shedding of the bacteria than vaccination of domestic stock that are artificially maintained in higher body condition through the winter time period.

The NPS is sensitive to the uncertainties of vaccinating wildlife and committed to implementing a program that maintains the wild character of the bison population while meeting the objective of lowering the risk of brucellosis transmission to cattle in Montana (Appendix F). The NPS has further clarified the description of alternatives in the FEIS (section 2.2) to include an adaptive management process that incorporates monitoring and research of vaccine efficacy, delivery, duration, safety, and diagnostics to answer uncertainties, make improvements, and attain reasonable assurances of success before implementing a costly, long-term, operational park-wide vaccination program. Under the no action alternative, the NPS could still evaluate effective outcomes of research (including pilot studies of vaccination), seek ways to minimize adverse impacts, and attempt to lower operational costs before reconsidering remote vaccination park-wide. The safety and well-being of the bison population is an important parameter that will be evaluated in conducting the adaptive management program.

CONCERN: The difficulty in monitoring the level of brucellosis infection within the population underscores the need for multiple indicators to measure the effectiveness of a vaccination program. Infection levels may be much lower than indicated by seroprevalence. Nonetheless seroprevalence should be monitored in combination with other indicators, such as bacterial cultures.

Quote(s): <u>Comment ID: 162655</u> Organization: Animal Welfare Institute
Representative Quote: "The difficulty in monitoring the level of brucellosis infection within the population underscores the need for multiple indicators to measure the effectiveness of a vaccination program. Most importantly, using seroprevalence as an indicator of infection does not involve killing the animals to obtain samples. Nonetheless it should be monitored in combination with other indicators, such as bacterial cultures. Seroprevalence indicates a history of exposures (i.e., antibody responses) and does not provide a complete picture of how bison may be responding to vaccination. Infection levels may be much lower than indicated by seroprevalence. Linking culture tests conducted on bison removed during management operations with their serology will provide a more accurate understanding of how bison are responding to vaccination and aid in brucellosis surveillance. (Treanor et al., 2007)."

Response: The NPS agrees that seroprevalence levels overestimate actual infection in a population and a monitoring program must be implemented that tracks multiple indicators of brucellosis infection, especially age-specific prevalence rates and probability of culturing bacteria from key lymph system tissues. A surveillance program has been initiated to track population-level infection and transmission rates. The surveillance program will also explore ways to quantify incidence and develop new monitoring methods. The surveillance program is common to all alternatives (section 2.2, FEIS) and the most-recent version is included as Appendix E.

Vaccine: Safety of Bison

CONCERN:	The vaccine is dangerous for the bison. Unforeseen consequences could include miscarriages, jeopardizing the last remaining wild bison population.
Quote(s):	Comment ID: 162848 Organization: Animal Welfare Institute Representative Quote: "Moreover, despite published evidence that the RB51 vaccine can and has induced abortions in bison vaccinated during the latter stages of pregnancy, the Subcommittee determined that it was unable to provide specific numeric estimates for abortions in pregnant bison induced by brucellosis vaccines. DEIS at 77. Though the NPS claims it will monitor vaccinated bison to look for evidence of abortions, since this is relevant to both the safety and efficacy of the vaccine, it would seem that the NPS should have a better answer to this question before even considering embarking on a vaccination program. This is particularly true considering that the NPS proposed to vaccinate bison both in the fall (mid-September through November) but also March through May, when vaccine use may have an adverse impact on bison based on the findings of Palmer et al. (1996) who reported that strain RB51 caused endometritis and placentitis resulting in abortions in pregnant bison vaccinated during the third trimester of pregnancy."
Response:	There is some evidence that pregnant adult bison vaccinated with any of the brucellosis vaccines may abort if vaccinated after the midpoint of pregnancy. The abortion rate from vaccinating pregnant bison is low based on clinical experiments and would not reduce reproductive rates to levels that jeopardize population persistence. However, evidence does indicate that bison vaccinated as calves or yearlings and subsequently re-vaccinated in later years have greater tolerance for the vaccine during pregnancy and exhibit greater immune system responses (Olsen and Holland 2003). Under adaptive management as part of the no action alternative, the NPS can further study the effects of vaccinating pregnant females.
CONCERN:	Yellowstone National Park discloses possible decision could result in the organism spreading and infecting more bison with more harmful and persistent variations of *Brucella abortus*.
Quote(s):	Comment ID: 162183 Organization: Greater Yellowstone Coalition Representative Quote: "One of the most striking elements of the remote vaccination proposal is the irreversible nature of some of the potential environmental consequences. As presently written, the DEIS downplays these irreversible outcomes, most dramatically if the program results in a mutated brucellosis organism is among the most severe examples of an irreversible commitment of resources. The statement in the DEIS that there are no appreciable irreversible commitments of resources is apparently inaccurate (DEIS at 118) given the other statements in the DEIS about the potential for causing vaccine-adapted variants that can spread in the population (DEIS at 73). The DEIS needs to address this possible outcome with a greater level of serious concern, and not ignore or downplay it in

evaluation of irreversible commitments of resources."

Response: There are no irreversible commitments of resources would be expected as the NPS has identified the no action alternative as the preferred alternative in this EIS. The cautions identified by scientists who have modeled evolutionary virulence by parasites focus on the competitive advantages of the vaccine-adapted parasite relative to a naïve parasite. This is presently a theoretical concept because there is no evidence this is occurring in *Brucella* species in response to vaccination. Viruses tend to exhibit this type of adaptive nature more so than bacterial parasites. Of most concern to the NPS is implementing a program that has the highest probability of gaining population immunity as quickly as possible and avoiding the pitfalls of slow accumulation of immunity. An adaptive management program and monitoring plan are included to resolve the uncertainty of whether vaccination can be effective and determine the feasibility of implementing a full-scale vaccination program with available methods. The ultimate goal would be a program that rapidly moves the population into a high level of immunity for brucellosis.

CONCERN: The biobullets could cause additional physical harm if they penetrate deeply and damage vital organs.

Quote(s): Comment ID: 162693 Organization: Animal Welfare Institute
Representative Quote: "Furthermore, the potential for shots to lodge in areas where there could be moderate to serious implications for the health of the animal cannot be discounted. Examples of such potential complications include: the laceration of the femoral artery; a biobullet lodging next to the sciatic nerve in one animal; biobullets lodging near nerves, major blood vessels, bones or joints that could have been irritated by the inflammatory reaction as the biobullet is absorbed; biobullets entering the rumen (though Quist and Nettles claim that this result was unlikely to cause harm); a biobullet that lodged in the spleen; two biobullets that entered the lungs which, in live animals, could have caused serious reduction in respiratory capacity potentially resulting in death; a biobullet that lodged near the left ventricle of the heart which could have had fatal consequences; and biobullets that lodged near the spinal cord, spinal nerves, jugular vein, and carotid artery. Admittedly, these potential complications depend on which area of the bison body (thigh, abdomen, shoulder, neck) is targeted for biobullet placement. The NPS doesn't disclose the recommended target area in the DEIS so it remains unknown as to which area the NPS may target and/or if any of the areas studied by Quist and Nettles, with the exception of the abdomen, could be targeted. Nevertheless, even if the NPS targets the thigh, for example, it is certainly not out of the question, particularly under field conditions, that a shot will not hit the intended target and could hit other areas on the bison where the potential complications could be more severe."

Response: The risks of vaccine delivery using bio-bullet technology are disclosed in the FEIS (section 4.2), and mitigation measures to avoid secondary physical harm such as delivery to visceral organs rather than muscle tissue or connective tissues were described in section 2.5 of FEIS. The NPS is concerned with the accuracy of vaccine delivery with this tool and will continue to develop application protocols to improve the accuracy of vaccine placement (section 4.2, FEIS and Appendix F). In the meantime, the NPS has identified the no action alternative in this EIS as the preferred alternative to guide the existing vaccination effort for Yellowstone bison.

CONCERN: The DEIS overestimates the probability of abortion events that would result from vaccinating pregnant bison.

Quote(s): Comment ID: 164136 Organization: United States Animal Health Association

Representative Quote: "Discussions of vaccine induced abortions resulting from Alternative C are described as adverse, direct, short-term, and minor (Table 5, p 47). The DEIS fails to acknowledge that while the likelihood of vaccine induced abortions in naïve, pregnant bison is low, the chance of abortions in bison that have received calfhood vaccination consistent with Alternative A and Alternative B is practically negligible."

Response: The probability of aborting a pregnancy following vaccination has been estimated in clinical experiments and will be evaluated further by the NPS. This is further addressed in the FEIS in Appendix F.

Vaccine: Effectiveness

CONCERN: This is an ineffective vaccine with a drawn-out schedule that is unlikely to achieve complete vaccination of Yellowstone's bison herd.

Quote(s): Comment ID: 153512 Organization Type: Unaffiliated Individual

Representative Quote: "There is no good reason to expect that there will be a very inefficient, but costly, delivery of effective doses of RB51 sufficient to create immunity in individual bison. . . . The effectiveness of RB51 against field strain *Brucella* is inconclusive. The reduction of infection is expected to be less than 10-15% (p. 17). Thus the proportion of approached and harassed animals that are successfully protected from infection will be extremely low. (Note that the probabilities described above must be multiplied. Thus, if 80% of bison can be approached and fired upon, with 95% success at hitting the bison, 70% penetration with a sufficient dose 90% of the time; and a 15% effectiveness of avoiding subsequent infection with Brucella: the ultimate success of activity will be (0.8) (0.95) (0.7) (0.9) (0.15) = 0.07; and the probabilities used here may be generous.)"

Response: The proportion of the population receiving vaccination is a parameter that can only be estimated by implementing a pilot program and calculating delivery rates and monitoring immune responses. Achievement of 100% vaccination is an ideal situation, but an unlikely scenario given the state of technology at this time. An effective disease management program would need to include alternate tools that increase population-level immunity other than vaccination (such as protection of non-infectious seropositive bison and selective removals of likely infectious bison) and be evaluated relative to the goals set by the program. The current goals include a substantial reduction in brucellosis seroprevalence relative to current estimates (section 2.2, FEIS). While the NPS has identified the no action alternative as the preferred alternative in this EIS, the agency is still responsible for working with the other IBMP partner organizations to evaluate and potentially resolve some of the issues that currently do not justify moving forward with remote vaccination, or abandon vaccination as a significant tool to be implemented for brucellosis management.

CONCERN: The biobullet delivery system, like any remote delivery system, would further reduce the vaccine's effectiveness. As the DEIS explains, "remote delivery systems are inherently complex and logistical and mechanical failures are inevitable."

Quote(s): Comment ID: 162846 Organization: Animal Welfare Institute
Representative Quote: “Can similar vaccine efficacy be expected from remote delivery compared to syringe delivery? Not surprisingly, again due to the multiple factors that may influence the efficacy of the vaccine under field conditions, the Subcommittee concluded that remote deliver induces protection that is less than hand vaccination but could not place a specific numerical value on the reduction. DEIS at 76. Other factors, not mentioned in the DEIS, that may also influence the efficacy of the vaccine under field conditions include wind velocity, ambient temperature, shooting distance to the target animal, and shot placement. These other factors were disclosed in Quist and Nettles (2003) and should have been, but were not, disclosed and discussed in the DEIS.”

Response: The NPS does not dispute that remote delivery would be less effective than vaccinating captured bison via syringe (section 4.2 in FEIS). The goal of the vaccination program has been disclosed in the EIS. Remote delivery of vaccine is a compromise that provides for less intensive handling and no capture of bison in the interior of the park, but results in an expected difference in immune response for an uncertain proportion of animals that are vaccinated. While the NPS identified the no action alternative in this EIS as the preferred alternative, there is expected to be additional research conducted to help evaluate the proportion of animals receiving a vaccine dose and the level of immunity provided by remote versus hand-delivered vaccine (Appendix F).

CONCERN: The vaccine intended for use does not provide levels of added protection against infection and abortions in bison substantial enough to justify the intrusive management envisioned by a 30-year remote vaccination program.

Quote(s):	Comment ID: 161471 Organization Type: Unaffiliated Individual Representative Quote: "The vaccine is not effective enough to give Yellowstone's buffalo sufficient protection from brucellosis. The DEIS admits the effectiveness of the RB51 vaccine is "not conclusive" even with the best delivery methods and adds that "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." Even the most rigorous proposed remote vaccination program (Alternative C) would result in less than 30% protection by the end of the 30-year project. . . . The biobullet delivery system, like any remote delivery system, would further reduce the vaccine's effectiveness. As the DEIS explains, "remote delivery systems are inherently complex and logistical and mechanical failures are inevitable."
Response:	The NPS recognizes that there is a broad constituency base with diverse values regarding what type of actions are appropriate for wildlife management programs in NPS units across the country. The NPS believes that a 50% reduction in seroprevalance rate would be a substantial improvement in the brucellosis status of the population and would result in a reduction of abortion events. However, the cost to implement and the sustained effort needed to reach that goal do not seem reasonable at this time. Thus, the NPS has identified the no action alternative in this EIS as the preferred alternative and has determined that additional research and development of tools for reducing brucellosis infection probability in Yellowstone bison is necessary before remote vaccination is reconsidered.

Vaccine: Other vaccines Considered

CONCERN:	The NPS should consider using other vaccines instead of or in addition to RB51.
Quote(s):	Comment ID: 154534 Organization Type: Unaffiliated Individual Representative Quote: "To be effective, at least two different vaccines for the same target organism should be alternated in livestock (such as horses, cattle, etc.). Otherwise, the target organism becomes immune to a single vaccine; humans will have spent vast sums of money on the target organism and lost the war." Comment ID: 162669 Organization: Animal Welfare Institute Representative Quote: "In regard to vaccine development, while there may not be any "new" vaccines currently available for use on bison, other wildlife, or livestock, there are other vaccines that have been used successfully against brucellosis in other countries and new vaccine technologies that are presently being explored. Even the NPS itself concedes that other vaccines, namely the strain 82 vaccine has been used successfully to reduce epizootic outbreaks of cattle brucellosis in Russia. DEIS at 75. Though the vaccine has had success in Russia, the NPS dismisses it from consideration for use in YNP because the findings and claims of the Russian scientists have not

been subject to peer-review or published in science journals for closer scrutiny. Though such concerns are apparently being addressed, it is unclear why this should prevent the initiate of safety and efficacy studies in the U.S. immediately to assess the suitability of using strain 82 vaccine in this country preferably as a new, potentially more effective treatment for domestic livestock. If the data from Russia is collected, analyzed, and published, AWI disagrees that it "will likely take decades to adequately test this select agent and gain approval for experimental use in wildlife," DEIS at 76, though AWI asserts that it would be more sensible to assess the suitability of this vaccine for use in domestic livestock, not wildlife."

Response: Strain 82 has not been approved for use in the United States and we are not aware of any ongoing experimental tests or efforts to license that vaccine for use in this country. Use of an older vaccine (Strain 19) was considered but dismissed (section 2.6, FEIS). The nature of the adaptive management program does not preclude the NPS from considering other vaccines as they become available for use.

CONCERN: RB51 is not a perfect vaccine; new research may provide new vaccines that would improve on the qualities of RB51. An adaptive management program is needed to allow the long term vaccination program to improve with technological advances.

Quote(s): Comment ID: 153684 Organization Type: Unaffiliated Individual
Representative Quote: "I am also glad to read that you will use an adaptive management approach. Clearly over time your staff will find better ways to administer remote *Brucella* vaccines. Also, as new technologies (oral vaccination, more advanced ballistic vaccination) and, hopefully, better vaccines become available, those should be employed."

Response: The goals of the program are to use the most effective vaccine available. The NPS has disclosed in the FEIS that as new vaccines become available they will be evaluated and changes will be implemented if new technology justifies an adaptive change.

Vaccine: Booster Vaccination

CONCERN: Booster vaccines have potential complications and should be given no more frequently than once per year.

Quote(s): Comment ID: 162850 Organization: Animal Welfare Institute
Representative Quote: "How frequently should bison be vaccinated? The Subcommittee reported that "it was unlikely that frequent vaccination would be beneficial" but that "annual vaccination of all female bison would most likely be most beneficial for maintenance of maximal protection." DEIS at 77. In other words, the annual vaccination of female bison would be beneficial but that vaccination frequency greater than one time per year would not be beneficial. While this may or may not be true, no data is presented by the Subcommittee or in its report to the USAHA Committee on brucellosis to substantiate this conclusion."

	Comment ID: 162851 Organization: Animal Welfare Institute Representative Quote: "Can bison be vaccinated too often? The Subcommittee assumed that multiple vaccinations would be safe in bison. DEIS at 77. It did so, as the NPS concedes, by excluding the possibility of syndromes associated with hyper-immunization - syndromes that were not disclosed or discussed in the DEIS - and despite the acknowledged limited data on the impact of multiple vaccinations on bison. DEIS at 77. This answer, like many of the others, suggests that the Subcommittee is so desperate to provide the NPS with a green light to proceed with a remote vaccination program regardless of the possible risks that it was willing to overlook the lack of data on the impact of multiple vaccination of bison or other potential complications of repeated vaccination of the same animal. Since scientists rarely draw conclusions based on a limited data set, if the Subcommittee members were unaware of the circumstances that lead to the NPS asking the questions in the first place, its possible that there answers may have been different or more measured depending on the availability and suitability of the data."
Response:	The concept of booster vaccination has been explored and is considered to be an effective approach to extending the duration of immunity in individuals as they age (Olsen and Holland 2003). This is further explained in the FEIS in sections 2.2, 2.5, and 4.2. The frequency of booster vaccination is an issue that needs further evaluation and will be pursued in additional research (as explained in the monitoring plan provided as Appendix E).

Other Wildlife (Safety of Other Wildlife, Proposed Action Does Not Address Transmission of Brucellosis by Other Wildlife)

CONCERN:	There is no way to significantly reduce brucellosis from the GYE because elk, deer, and other mammals in the system will still carry the disease.
Quote(s):	Comment ID: 161147 Organization: Gallatin Wildlife Association Representative Quote: "We are concerned the draft bison vaccination proposal fails to recognize and discuss the bigger ecological picture as it relates to wildlife management, livestock management, brucellosis and other exotic disease presence within the Greater Yellowstone Area. For example, wildlife feed grounds are a significant contributor to the potential exposure and infection rates of exotic diseases found in native elk and bison in the Greater Yellowstone Area (Smith 2000; Smith 2001: Ferrari and Garrott 2002; Etter and Drew 2006; U.S. Fish & Wildlife Service and National Park Service 2007; Maichak et al. 2009). Greater Yellowstone elk are known to be endemically infected with brucellosis, are much more numerous and use a much larger landscape than bison currently do within the Greater Yellowstone Area (Montana FWP undated; Montana FWP 1992; Keiter 1997; Smith 2000; Smith 2001; Hamlin and Ross 2002; Montana FWP 2004; Etter and Drew 2006; Griggs

2007; Hamlin and Cunningham 2009; Cross et al. 2010). As well, Greater Yellowstone elk are known to be exposed to numerous other exotic livestock diseases (Thomas and Toweill 1982; Hamlin and Ross 2002). Many other Greater Yellowstone wildlife species have been exposed to brucellosis as well other exotic livestock diseases and this has not been adequately revealed in the DEIS. These important ecological considerations and interactions should be clearly discussed in the final EIS. We see little realistic benefit for a proposal that singles out brucellosis in bison in Yellowstone National Park given the reality and complexity of the interconnected Greater Yellowstone Ecosystem."

Response: The NPS acknowledges that a significant reduction in brucellosis prevalence (90% less than current estimates) is not feasible given the currently available vaccines, delivery methods, and ecology of the wildlife species of interest (FEIS section 2.2). While the goal of the proposed action is to reduce brucellosis prevalence in Yellowstone bison, the NPS has identified the no action alternative as the preferred alternative with an adaptive management strategy to focus on research that evaluates how to monitor shedding, clinical signs of brucellosis in vaccinated bison, and better understanding the threshold for action that may accomplish a significant reduction in brucellosis prevalence.

The NPS considers elk and bison to be the significant wildlife hosts of this disease in the GYE. The NPS along with its interagency partners implements actions to prevent brucellosis transmission from bison to livestock per a court-mediated settlement (2000 IBMP). The contribution of elk to potential transmission of the disease to cattle is mentioned in the FEIS in section 1.1. However, detailed analysis of elk brucellosis transmission to cattle is outside the scope of this EIS.

Literature does not support the theory that other animals such as deer, small mammals, or birds, transmit the disease to cattle. Whether brucellosis prevalence can be reduced in all species across the GYE is also outside the scope of this EIS. Other agencies are addressing brucellosis infection in elk in other places around the GYE (Chapter 4, Section 4.2).

CONCERN: The potential impacts to other wildlife from the proposed plan should be more thoroughly addressed in the DEIS and should include, but not be limited to: 1) the effects of a non-target animal's consumption of a biobullet and/or a vaccinated carcass; 2) the physical injuries to a non-target animal's body from being directly or indirectly hit with a biobullet; 3) the long-term results of the vaccine on a non-target animal's health after being accidentally hit; and 4) the trauma/stress to non-target species resulting from the proposed vaccination program activities, such as aerial delivery mechanisms, human approach, bison stampede, etc.

Quote(s): <u>Comment ID: 162726</u> Organization: Animal Welfare Institute
Representative Quote: "Finally, in evaluating the potential of non-

target species to eat the vaccine-laden biobullet, the NPS claims that "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," DEIS at 100, and that there is a "low probability that any wildlife species would eat the projectile." Id.

These statements appear to be entirely speculative as the NPS provides no evidence to substantiate these claims; claims that, frankly, don't make a lot of sense. For example, why would non-target species not potentially eat the projectile? Surely, the curiosity of some species may cause them to explore a deflected biobullet. Moreover, given the strong sense of smell that most wildlife species have, some may be attracted to the smell of the biobullet. Depending on the animal's level of hunger and/or the attractiveness of the biobullet as a potential food source, the NPS should not be so flippant of the potential for non-target species to consume biobullets. Admittedly, in time, depending on weather conditions, the biobullet will degrade but, at least for a short period of time, a deflected biobullet could be consumed by any number of non-target species.

Similarly, if a biobullet were to be consumed it doesn't make sense, as the NPS suggests, that the amount of the vaccine consumed from the projectile would be of lower impact of that from an encounter with a vaccinated bison carcass. One would think that the amount of the vaccine in the carcass would be far lower than what would potentially be in a deflected biobullet since the target animal, prior to its death, must have absorbed some or all of the vaccine to the point where a full dose of the vaccine would not be available to be consumed even if an entire carcass is consumed by a single animal. The NPS must provide further analysis of the potential for and implication of a non-target species consuming a biobullet and the risk of doing so compared to the risk of consuming a vaccinated bison carcass."

Response: Exposure to the *Brucella abortus* bacteria through ingestion or mucus membrane exposure has been studied for numerous non-target animals that are likely to encounter carcasses of vaccinated bison. Impacts to other wildlife species have been disclosed in sections 1.1 and 4.3 of the FEIS.

CONCERN: The DEIS overestimates the negative effects of incidental exposure to the vaccine by non-target animals.

Quote(s): <u>Comment ID: 153698</u> Organization: Wyoming Livestock Board
Representative Quote: "Also, to address the environmental safety and non target species concerns listed in the DEIS, we refer you to a publication by Dr. Jack Rhyan (2002), "Brucellosis Vaccines and Non-Target Species". These authors found that the safety of RB51 has been extensively studied in many wildlife and domestic species including deer mice, ground squirrels, prairie voles, ravens, coyotes,

moose, big horn sheep, mule deer, pronghorn, domestic dogs, elk, and black bears. The vaccine has not caused any significant problems in any of the species examined. (For a summary of results, see Cook and Rhyan, 2002). Thus, we do not believe that there is any reason to be concerned about any impacts from the vaccine to non-target species. Even though grizzly bears and gray wolves have not been specifically studied, the fact that RB51 is safe in black bears, coyotes, and dogs strongly suggests that it would be safe in these predators as well. Of the federally threatened species, only the Canada lynx has not had a close relative studied for safety to the vaccine. However, the wide range of species shown to have no adverse reaction to the vaccine and the fact that all predatory species in the GYA have potential exposure to field strain *Brucella abortus* with no adverse impacts reported suggests that RB51 would be safe in the Canada Lynx as well."

Response: The FEIS (section 4.3) discloses the effects to non-target wildlife species as reported in clinical experiments.

Yellowstone Bison Population: General Comments Related to Brucellosis Prevalence

CONCERN: The NPS needs to manage herd numbers to a smaller size, which will curtail bison from leaving the park in search of food and will result in minimizing contact between bison and cattle, therefore reducing brucellosis prevalence.

Quote(s): Comment ID: 151812 Organization Type: Unaffiliated Individual
Representative Quote: "Another reason why this is a good plan is because the IBMP allows for the bison of Yellowstone National Park to be a free ranging herd as the wildlife of the park is intended to be. In "Wildlife-livestock conflict" an ecology study found that the buffalo of Yellowstone prefer their home in the park. These researches also looked at the threat these buffalo present when they are out of the park to spreading brucellosis to cattle herds. They focused their efforts on two areas where buffalo are allowed to winter in Montana. They conclude that when buffalo numbers are high and resources are scarce more buffalo will be more likely to leave the park and winter outside its boundaries causing a potential risk for disease transmission (Daszak et al., 2009)."

Response: The commenter is most likely referring to a paper by Kilpatrick et al. (2009), which is cited in the FEIS. Pursuant to the court-mediated settlement that directed the IBMP and subsequent adaptive management adjustments, the Yellowstone bison population is managed towards an end-of-winter target of 3,000 bison, but has ranged between 2,500 and 5,000 bison in recent decades.

CONCERN: The no action alternative is ineffective at reducing disease prevalence, supported by data collected since the IBMP was enacted.

Quote(s): Comment ID: 152891 Organization: United States Animal Health Association
Representative Quote: "Expected outcomes of Alternative A relating

to reducing prevalence of brucellosis in Yellowstone bison are incongruent with the approach described with this Alternative. Between the years of 2000 and 2010, the DEIS reports that 136 animals were vaccinated at the Stephens Creek capture facility. It is unreasonable to expect a measurable decrease in brucellosis prevalence following the vaccination of only 3% of the birthed animals (based on 150 calves birthed annually per 1000 bison over 10 years with a population of 3000 bison). Indeed, the prevalence of brucellosis in the Yellowstone bison population remains unchanged over the last 10 years and supports concerns that Alternative A would not yield a measurable impact. . . . The same concerns apply to expected impacts on shedding, herd immunity and transmission (Table 5, p48)."

Response: The NPS has reported that brucellosis management actions to date have not reduced brucellosis prevalence in Yellowstone bison (White et al. 2011, 2013). Those analyses also note that vaccination has not been consistently implemented as described under Alternative A by either the NPS (north management area) or the State of Montana and the Animal and Plant Health Inspection Service (west management boundary).

The NPS has identified the no-action alternative as the preferred alternative in this EIS, with an adaptive management program to answer uncertainties, improve technology, minimize adverse impacts, and lower operational costs. Remote vaccination could be reconsidered in the future if advances in technologies and techniques for vaccines, delivery, and diagnostics occur.

Yellowstone Bison Population: Immunity to Brucellosis Generated by Exposure to Field Strain

CONCERN: The *Brucella abortus* bacteria are endemic to the YNP bison population and long-term exposure to the bacteria has resulted in a far lower abortion rate when compared to what may occur in an immunologically naive population of bison.

Quote(s): Comment ID: 162886 Organization: Animal Welfare Institute
Representative Quote: "The NPS claims, citing Olsen et al. 2003, that following brucellosis infection, 96% of bison females are expected to abort their first pregnancy. DEIS at 84. Though this study could not be obtained for review, is believed that Olsen et al. used seronegative, immunologically naïve bison in their experiment raising questions about whether the 96% abortion rate can be applied to YNP bison. Nevertheless, if this rate of abortions predicted by Olsen et al. was true, considering how closely YNP bison are monitored, particularly those outside of the park, there would be far more instances of documented YNP bison abortions. There are, however, few such documented instances largely because the frequency of *Brucella*-induced abortions in bison is incredibly small. This may be a result of the bacteria being considered endemic to the population and that the chronic and long-term exposure of bison to the bacteria has resulted in a far lower abortion rate compared to what may occur in an

immunologically naive population or individuals."

Response: The *Brucella* bacteria are thought to have been introduced to the area by cattle brought in to feed the visitors and early employees of Yellowstone National Park. The NPS agrees that chronically infected populations likely evolve to result in lower abortion rates than newly exposed populations. Vaccination is a tool used to facilitate an increase in population immunity that can otherwise be generated through exposure to field strains.

CONCERN: This program is only to benefit the cattle, because the bison are not suffering negative consequences from brucellosis.

Quote(s): <u>Comment ID: 142490</u> Organization Type: Unaffiliated Individual
Representative Quote: "Wild buffalo have developed their own immunity against brucellosis since contracting it from cattle over 100 years ago."

Response: Chronic brucellosis infection does not adversely affect the long-term viability of Yellowstone bison, but does significantly decrease bison calving rates and, in turn, the rate of population growth (Fuller et al. 2007b, Geremia et al. 2009). Also, brucellosis has prevented the use of the unique wild state and adaptive capabilities of Yellowstone bison to contribute to the restoration of the species in the greater Yellowstone ecosystem and elsewhere.

CONCERN: Sending bison to slaughter for testing positive for brucellosis antibodies means that you are slaughtering some of the very bison that should be maintained in the population because they have developed an acquired immunity to the bacteria and recovered from the infection.

Quote(s): <u>Comment ID: 162894</u> Organization: Animal Welfare Institute
Representative Quote: "This finding is entirely consistent with what AWI, this author, and many other interest groups and scientists have been saying for years and which is supported by the scientific literature; that exposure to field strain early in life provides bison with an acquired immunity to subsequent exposures and infections. The immunity acquired is not likely to be 100% so there may be bison that can be re-exposed and will develop a new infection but the fact, as Geremia et al. demonstrate, that this natural form of immunization exists within the YNP bison populations provides additional reason as to why the IBMP strategy of capture and slaughter and capture, test, and slaughter must be revisited. Indeed, the agencies, led by the NPS, by failing to base their management practices on sound science, have, are, and will continue to slaughter some of the very bison who should be maintained in the population because they have been exposed to the bacteria, have cleared an infection (if an infection occurred), and now have an acquired immunity to the bacteria."

Response: Seropositive bison that recover from a brucellosis infection are less likely to shed the bacteria and may contribute to population immunity (resistance) to future transmission. This specific recommendation from the commenter is a part of the actions common to all alternatives (section 2.2 in the FEIS). The decision to slaughter all bison that test positive for brucellosis antibodies was part of the initial IBMP and is not part of this proposed action. However, the NPS has proposed that approaches which target female bison for vaccination, while removing bison likely to be infectious based on age and assay results and retaining other seropositive bison in the population for some immunity (resistance), may be effective at reducing brucellosis infection (Treanor et al. 2011).

Yellowstone Bison Population: Levels of Tolerance for Bison Outside of Park/Cattle Industry Concerns

CONCERN: Livestock industry constituents dispute the DEIS statement that the proposed remote delivery program will not reduce seroprevalence sufficiently to alter perceptions of livestock operators, producers and regulators regarding risk of transmission from bison to cattle. Alternative C should reduce seroprevalence over many years to sufficiently reduce shedding of bacteria and prevalence of brucellosis in bison, which in turn will alter the perceptions of livestock stakeholders regarding risk and quality of partnerships with NPS.

Quote(s): Comment ID: 164137 Organization: United States Animal Health Association

Representative Quote: “USAHA does not agree with the statement in the DEIS that "the proposed remote delivery vaccination actions 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." The implementation of Alternative C will dramatically alter perceptions of risk and NPS' commitment to reduce brucellosis in the GYA [greater Yellowstone area].”

Comment ID: 145395 Organization: Montana Department of Livestock

Representative Quote: “MDOL does not agree with the statement in the DEIS that "proposed remote delivery vaccination actions 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." The implementation of Alternative C will alter perceptions of risk and NPS' commitment to reduce brucellosis in the GYA.”

Response: The NPS has acknowledged these statements in the FEIS and will work in collaboration with the State of Montana to clarify the level of tolerance that the state will provide for bison. The court-mediated settlement in 2000 (IBMP), and subsequent adaptive management adjustments, have increased tolerance for Yellowstone bison on low-elevation winter ranges in Montana. In addition, the NPS has initiated and/or proposed actions to reduce brucellosis prevalence, including continued vaccination of females and the removal of likely infectious bison (based on age and assays) at the Stephens Creek capture facility.

CONCERN: The vaccination program will have little influence over increasing tolerance for bison outside park boundaries.

Quote(s): Comment ID: 142811 Organization Type: Unaffiliated Individual
Representative Quote: “The Executive Summary indicates that "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". That sentence is not correct. Initiation of remote vaccination affects the level of tolerance for untested bison in Zone 2, consistent with Step 3 in the adaptive management framework in the IBMP. It should be emphasized that the boundaries of Zone 2, as defined in the IBMP, will be unaffected by a decision to implement remote vaccination. Further, it should be noted that, given the practical limitations of implementing the IBMP and political pressure in opposition to the removal of bison, the agencies already are tolerating more untested bison in the western boundary area than the limits defined for Step 3 even though the adaptive management criteria for moving to Step 3 have not yet been satisfied. As a consequence, remote vaccination will have little influence on increased tolerance for bison in Zone 2, relative to the no action alternative.”

Response: The NPS will work in collaboration with the State of Montana to clarify the level of tolerance that the state will provide for bison. The court-mediated settlement in 2000 (IBMP) was resolved by the state agreeing to increase tolerance for wild bison outside Yellowstone National Park in a systematic process following: 1) a learning strategy to figure out if the interagency partners could learn to manage distribution by hazing and capture of bison; 2) a research project to estimate the life expectancy of *Brucella* bacteria that is shed by infected bison in the boundary management areas; and 3) the development of a vaccination program for bison to reduce the amount of *Brucella* bacteria shed by the bison population in the area where bison overlap their range of distribution with domestic livestock. Subsequently, adaptive management adjustments have increased tolerance for Yellowstone bison on low-elevation winter ranges in Montana to accommodate hunting by Montana-licensed and tribal treaty hunters. The NPS has initiated and/or proposed actions to reduce brucellosis prevalence, including continued vaccination of females and the removal of likely infectious bison (based on age and assays) at the Stephens Creek capture facility. The adaptive management program proposed in this FEIS describes how further study of vaccination could be conducted to attain the knowledge needed to reconsider expanding the current boundary area vaccination efforts of the partner agencies.

CONCERN: This proposed vaccination program stems from the continual and ongoing pressures from the livestock industry and grazing organizations in the western U.S.

Quote(s): Comment ID: 156639 Organization Type: Unaffiliated Individual
Representative Quote: "In fact, the remote vaccination plan has been primarily proposed to appease a small special interest group: local livestock producers."

Response: This EIS evaluating remote vaccination stems from a court-mediated settlement (IBMP) to resolve a legal proceeding in which the State of Montana sued the federal government over conflicting goals for managing Yellowstone bison and how the USDA would regulate the state's livestock industry should Yellowstone bison migrate to lands in the State of Montana.

Yellowstone Bison Population: American Indian Considerations

CONCERN: Vaccinating wild bison is culturally unacceptable to American Indian tribes and to all Americans who honor wildlife.

Quote(s): Comment ID: 143525 Organization: *Not Specified*
Representative Quote: "Vaccinating wild buffalo is culturally unacceptable to American Indian tribes and to all American's who honor wildlife."

Response: The NPS reached out to 26 associated tribes to seek information through consultation on this EIS. The NPS recognizes, through oral communications with tribes during consultation meetings, that some American Indians do not support the idea of vaccinating Yellowstone bison. However, this was not a universal response. The single written response received from tribes through the consultation process was a comment in support of remote vaccination to better control brucellosis problems. In addition, the NPS engaged with over 60 tribal contacts not directly associated with Yellowstone National Park, but interested in Yellowstone bison, during the review of the DEIS. No additional information concerning the cultural acceptance of vaccination to tribes was received.

CONCERN: Yellowstone National Park needs to evaluate and disclose how it intends to address traditional cultural concerns raised by tribes in consultation (DEIS, 64).

Quote(s): Comment ID: 162542 Organization: Buffalo Field Campaign
Representative Quote: "Yellowstone National Park needs to evaluate and disclose how it intends to address traditional cultural concerns raised by tribes in consultation (DEIS, 64) including: 1) Respectful treatment of the bison, including allowing them to roam freely without fencing or disrespectful hazing; 2) Vaccine contamination of meat for consumption and ceremonial purposes; and 3) Preservation of wickiups, stone alignments, and other cultural features associated with bison. Indigenous knowledge, cultural relationships and perspectives on wild buffalo held in your trust need to be evaluated and disclosed. In your analysis and decision, the Park needs to

redress indigenous spiritual and cultural values held for wild bison, and adopt management approaches for wild bison remaining in your jurisdiction that reflect traditional ecological knowledge of indigenous peoples."

Comment ID: 153814 Organization: InterTribal Buffalo Council
Representative Quote: "Notwithstanding these perception issues, ITBC is concerned about the program's efficacy rates, cost effectiveness, practicality, and significantly, its consequences for efforts to increase transfers to Tribal management facilities. ITBC remains committed to transferring available bison to Tribal bison management programs when possible and is actively pursuing efforts to ensure that these programs are a meaningful and prioritized management option consistent with the Interagency Bison Management Plan. In addition to being a culturally important animal, bison are also a significant resource for tribal economic development and are marketed for consumption. The EIS notes that the vaccine takes about 21 days to clear an animal's system and meat should not be consumed at least until after this program has elapsed. However, no sufficient tracking system is proposed to ascertain individual vaccinated animals for the 21 day period. The EIS proposes to use paintballs to track vaccinated bison but there is no further explanation as to how long the marking will last or how effective this method is.

As tribes remain potential recipients of surplus bison consistent with the IBMP, the vaccination program provides no assurances that the animals would be safe to market or consume. Thus, this program creates health and economic risks to tribes as a viable management option by compromising bison consumption safety and marketability. These same risks for consumption also extend to the tribes' treaty hunts as it would be difficult for hunters to ascertain whether an individual bison was safely out of the 21 day post vaccination period."

Response: Bison vaccination will likely occur as a pedestrian activity and will be designed to minimize stress on the animals. No fencing will be involved. Hazing is used in attempts to keep bison separated from cattle and within the boundaries of the agreed-upon conservation area per the IBMP, and is beyond the scope of this EIS. The EIS discloses the withdrawal time of 21 days following vaccination as a conservative measure of safety to prevent contamination of the meat of vaccinated bison which is the required time per the Food and Drug Administration (section 4.5, FEIS). By selecting the no action alternative, the NPS has the ability to maintain vaccinated bison in captivity through the 21-day withdrawal period if individuals have a reasonable chance of being harvested through tribal hunting programs. The EIS contemplates actions which do not have the potential to damage or alter wickiups, stone alignments, or other cultural features associated with bison. No construction activities or ground-disturbing activities are planned within the scope of this planning effort.

Indigenous knowledge, cultural relationships, and perspectives on wild bison are important to this planning effort. The park has been told during previous consultation meetings that vaccination of bison was not supported by some tribes. However, alternatives to vaccination which would lower the brucellosis infection rate have not been provided by tribal members. While tribes have consistently conveyed that bison represent a significant cultural, nutritional, and spiritual resource, the NPS has not been advised of any tangible effects that bison vaccination will have on this relationship. Should any impacts be identified the NPS would attempt to mitigate through altering management actions.

Yellowstone Bison Population: Safety/General Welfare of Bison

CONCERN: This harmful remote vaccination plan will be stressful and traumatizing to the animals.

Quote(s): Comment ID: 153825 Organization Type: Unaffiliated Individual
Representative Quote: "I am opposed to the remote vaccination program on the following grounds: The potential for adverse impacts on the health of Yellowstone's wild bison population, including both immediate side effects from the vaccine and long-term consequences, is substantial and has not been adequately studied. Potential impacts of follow-up studies and long-term monitoring, which would require invasive procedures such as tranquilizing, capturing, radio collaring, implantation of vaginal transponders, drawing blood, etc. have not been adequately investigated or disclosed. Yellowstone's bison are already subject to numerous invasive studies such as the recent APHIS [Animal and Plant Health Inspection Service] venereal transmission study, radio collaring and tracking, and incessant hazing and harassment. Cumulative stress is difficult to quantify but behavioral changes due to incessant human intervention are inevitable and such intrusive management practices are likely to be harmful in the long term."

Response: The NPS has identified the no-action alternative as the preferred alternative, with a research program to answer uncertainties, improve technology, minimize adverse impacts, and lower operational costs. Remote vaccination could be reconsidered in the future.

Appendix C: 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 April through June 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. 2007, 2008). Marking of individuals on a short-term basis (such as with a 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. 2012b). 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 (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%. Also, sampling at numbers greater than 250 individuals does not significantly improve the probability of detecting a change in seroprevalence (Ebinger and Cross 2008).

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 April through June. As the program evolves and seroprevalence in young adults decreases, vaccination of adult females will increase in priority.

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 a 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 (ear tag placement, passive integrated transponders) of bison handled in capture facilities near the park boundary and during 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.

Cost Estimate for Additional Studies Needed to Resolve Uncertainties and Improve Efficacy of Delivery and Monitoring of Results

$5,000	Evaluate the effectiveness of Polymerase Chain Reaction test procedures to identify likely infectious bison (Collaboration with Idaho National Engineering and Environmental Laboratory)
$10,000	Vaccinate adult females in last trimester of pregnancy to determine if the risk of inducing vaccine-caused abortion is low (Collaboration with Agriculture Research Service, Ames, Iowa)
$15,000	Develop and validate a production protocol to include quality control over remote delivery products needed for use in vaccination program (Collaboration with University of Utah)
$200,000	Captive study to determine the strength and duration of the immune response in bison following hand-syringe or remote-delivery vaccination for brucellosis via biobullet (including booster vaccination within or between years).
$60,000	Conduct a pen study to evaluate bison immune responses using remote delivery compared to hand-syringe delivery (Collaboration with Agriculture Research Service, Ames, Iowa)
$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 (Collaboration with University of Utah)
$30,000	Develop a validated RB51 *Brucella abortus* ballistic vaccine product prototype, formulated as a single component two-stage vaccine+booster payload, compatible with available remote delivery equipment (Collaboration with University of Utah)
$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
$180,000	Field study to evaluate the difference in variability in immune response provided by remote vaccination compared to a controlled pen study
30,000	Modeling alternate scenarios to identify the feasibility of accomplishing the infection reduction goal
$560,000	***Research Subtotal***

Cost Estimate for Necessary Equipment (One-time Purchase)

$4,000	Chemistry equipment to do encapsulation work
$5,000	Remote delivery rifles
$3,000	Compressed air-powered paint ball pistols/rifles
$5,000	Optical equipment such as scopes, binoculars, and rangefinders
$17,000	***Equipment Subtotal***

Annual Cost Estimate for Remote Delivery Program

$6,000	Aerial survey to direct ground crews
$108,000	Staff to conduct vaccination program (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 (bear spray, safety supplies, batteries, optics, ski gear)
$12,000	Contract to procure vaccine
$144,600	***Annual Field Delivery Subtotal***

Cost Estimate for Hand-Syringe Delivery Program at Capture Pens

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 hand-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. The additional costs for hand-syringe vaccination are about $25 to $200 per year depending on the number of vaccine eligible bison that are released following testing for brucellosis.

Funding Sources and Cost Estimate for Monitoring Program

Potential funding sources for monitoring activities to assess the effects and effectiveness of the IBMP, including in-park vaccination are indicated in Table C1.

Stephens Creek

The current monitoring 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. The data used to monitor population seroprevalence is the same information required to determine how to manage risk of transmission at the boundary capture pens. The following is an estimate of those annual testing costs:

$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 (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***

Field Monitoring of 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
$15,000	Behavioral response monitoring to quantify response to approach and remote delivery of projectiles.
$57,000	***Annual Field Monitoring Sub-total***

Updating system models to allow continued predictions for adaptive management
Models used to make projections about demographics and disease dynamics are only able to reliably predict outcomes of management actions a few years forward. To provide the best projections, inputs for model variables must be updated annually and process models rerun to provide managers good estimates of how the population is responding to the management actions implemented. Costs to update projection models by collaborative scientists would be about $10,000 per year.

Projected Cost per Proposed Alternative

Alternative A
Vaccination delivery and monitoring is conducted at the boundary capture pens ($102,000). Modeling to provide managers with predictions for the adaptive management program would cost about $10,000. Total expenses to implement Alternative A are $112,000.

Alternative B
Vaccination delivery would include research conducted by IBMP members and academic institutions away from Yellowstone National Park, vaccination at the boundary capture pens, and remote delivery of encapsulated vaccine to calves and yearling bison throughout the park.

Research studies	$560,000
One-time equipment purchase	$ 17,000
	$577,000

Modeling to provide adaptive management predictions	$ 10,000
Annual vaccine delivery costs	$144,600
Annual monitoring costs	$158,000
	$312,600

Alternative C

Vaccination delivery would include research conducted by IBMP members and academic institutions away from Yellowstone National Park, vaccination at the boundary capture pens, and remote delivery of encapsulated vaccine to calves and yearling bison throughout the park. The cost to implement this alternative is about the same as the cost to implement Alternative B. The slight difference would be the number of individual bison that receive vaccine projectiles. All monitoring costs and efforts would be similar for Alternatives B and C.

Research studies	$560,000
One-time equipment purchase	$ 17,000
	$577,000

Modeling to provide predictions	$ 10,000
Annual vaccine delivery costs	$144,600
Annual monitoring costs	$158,000
	$312,600

Table C1. Current funding sources for monitoring activities to assess the effects and effectiveness of the Interagency Bison Management Plan (IBMP), including vaccination.

Monitoring 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 (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 hand-syringe delivery vaccination for brucellosis.	X	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

Appendix D: 106 Consultation Concurrence Letter

2006121305

United States Department of the Interior

NATIONAL PARK SERVICE
PO Box 168
Yellowstone National Park
Wyoming 82190

IN REPLY REFER TO:

RECEIVED
DEC 18 2006
SUPERINTENDENT'S OFFICE

H3015(YELL)
xN1427

DEC 1 1 2006

CONCUR
MONTANA SHPO
DATE 12/15/06 SIGNED

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
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Fax: (307) 777-6421
http://wyoshpo.state.wy.us

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

Appendix E: Monitoring Plan (2012)

The successful conservation of plains bison (*Bison bison*) in Yellowstone National Park from about two dozen animals in 1901 to 5,000 animals in 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 (Plumb et al. 2009). Also, since the State of Montana and the National Park Service (NPS) agreed to the court-mediated Interagency Bison Management Plan (IBMP; United States Department of the Interior [USDI] and United States Department of Agriculture [USDA] 2000a, b), progress has been slow at completing the plan's successive management steps. Thus, the Government Accountability Office (2008) recommended the IBMP agencies develop specific management objectives, conduct monitoring to evaluate the effects and effectiveness of management actions, and develop methods for adjusting the IBMP based on monitoring.

These recommendations were implemented by the IBMP agencies through an adaptive management plan in 2008 (USDI et al. 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 (USDI, NPS 2010a). Thus, there is a need to estimate key parameters of bison and brucellosis dynamics, and evaluate the likely effects and effectiveness of a variety of management activities. This plan identifies and reports on a suite of long-term monitoring and research activities for Yellowstone bison that meet the mission of the NPS and inform adaptive management.

The various types of actions in the IBMP to ensure the conservation of a viable, free-ranging bison population while safely and effectively reducing infection from, and transmission of, the non-native *Brucella* bacteria can be grouped into three general categories: 1) managing brucellosis transmission risk; 2) reducing the prevalence and transmission of brucellosis; and 3) conserving a viable population of wild bison and the ecological processes that sustain them (Figure 1). Thus, we developed management and research objectives for these desired conditions that are multidimensional and involve trade-offs, whereby improving an outcome associated with one objective affects outcomes associated with other objectives (Williams et al. 2007). We also developed one or more sampling objectives for each monitoring activity (White et al. 2008).

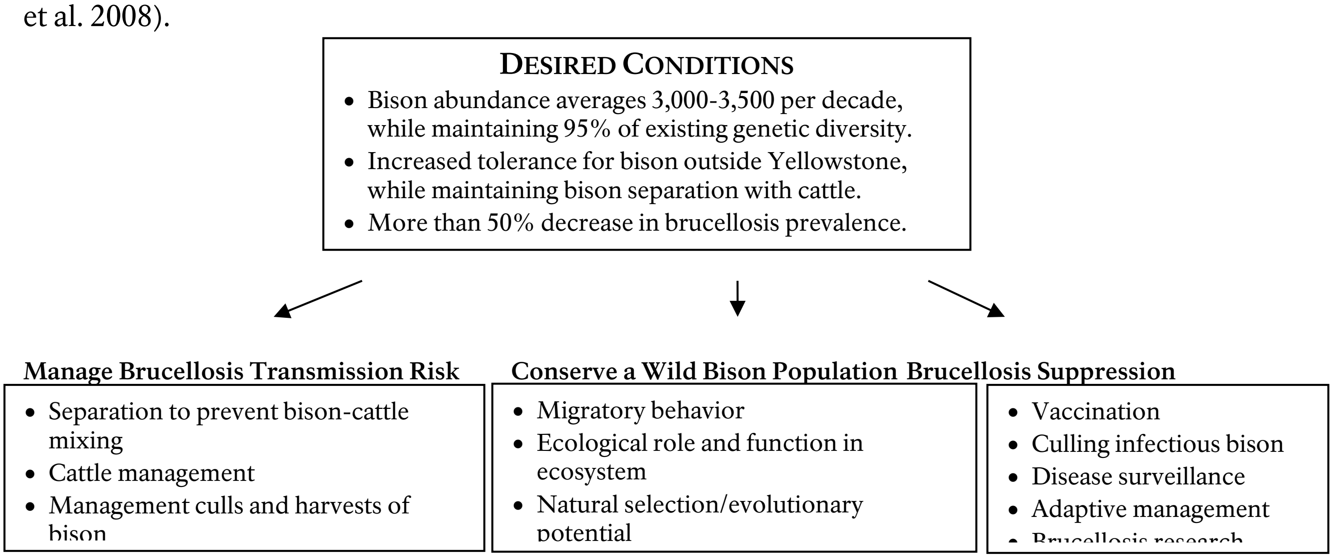

Figure 1. Conceptual model of conservation and disease management for Yellowstone bison.

We then developed the following monitoring activities to provide timely and useful information to help develop adaptive management adjustments.

Conservation (Preserve a Functional, Free-Ranging Bison Population)

1. Estimate the abundance, demography, and limiting factors for the overall bison population and two primary subpopulations (i.e., central and northern breeding herds).
2. Describe migratory and dispersal 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.
4. Promote cooperative conservation in bison management by partnering with states, tribes, and others interested in bison health and recovery.

Risk Management (Prevent Brucellosis Transmission from Bison to Livestock)

5. Estimate the probabilities (i.e., risks) of brucellosis transmission among bison, cattle, and elk, and between the elk feed grounds in Wyoming and northern Yellowstone.
6. Estimate age-specific rates of bison testing seropositive and seronegative for brucellosis that are also culture positive, and the portion of seropositive bison that react positively on serologic tests due to exposure to cross-reactive agents other than *Brucella abortus* (e.g., *Yersinia*).
7. Estimate the timing and portion of removals from the central and northern herds each winter, including the portion of removals from each age and sex class and calf-cow pairs.
8. Document bison use of risk management zones outside the northern and western boundaries of Yellowstone and mingling with livestock during the likely brucellosis-induced abortion period for bison each spring.
9. Estimate the effects of hazing or temporarily holding bison in capture pens at the boundary of Yellowstone (for spring release back into the park) on subsequent bison movements or possible habituation to feeding.

Brucellosis Suppression (Reduce Disease Prevalence)

10. Determine the strength and duration of the immune response in bison following hand-syringe delivery vaccination for brucellosis.
11. Determine the strength and duration of immune response in bison following remote delivery (e.g. bio-bullet) vaccination for brucellosis.
12. Document long-term trends in the prevalence of brucellosis in bison, and the underpinning effects of remote and/or syringe vaccination, other risk management actions (e.g., harvest, culling), and prevailing ecological conditions (e.g. winter-kill, predation) on these trends.

IMPLEMENTATION AND EXPECTED OUTCOMES

To accomplish this suite of monitoring activities, NPS staff work with the other IBMP members (Animal and Plant Health Inspection Service, Confederated Salish and Kootenai tribes, InterTribal Buffalo Council, Montana Department of Livestock, Montana Department of Fish, Wildlife, and Parks, Nez Perce Tribe, U.S. Forest Service), and other scientists and stakeholders to implement field, controlled, and laboratory studies to collect empirical data for evaluating progress. The data are used to develop and parameterize models that serve as analytical tools for evaluating how bison and brucellosis may respond to management actions within specified confidence bounds. The IBMP members produce an annual report that describes monitoring activities, the status of Yellowstone bison, and relevant brucellosis management issues. This report is disseminated at <www.ibmp.info>. The Wildlife Biologist leading the Bison Ecology and Management Program at Yellowstone is responsible for managing the monitoring system and producing the monitoring portion of the annual IBMP report. This monitoring plan will also be posted at <www.ibmp.info> and analyses, and as appropriate, articles resulting from monitoring will be subject to peer review by other scientists from the NPS, agency partners, and/or anonymous reviewers selected by editors of scientific journals. Pursuant to Bulletin M-05-03 issued by the Office of Management and Budget on December 16, 2004, the intensity of peer review will be commensurate with the significance of the information being disseminated.

Success in adaptive management ultimately depends on effectively linking monitoring and assessment to objective-driven decision making (Williams et al. 2007). 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 partners; and 3) communicating with and engaging key stakeholders (U.S. Government Accountability Office 2008). This monitoring 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. It will also allow IBMP managers to track system responses to these management actions through continuation of monitoring. Examples of actions by the NPS that monitoring may trigger based on the information collected include:

- Deciding whether or not to implement remote vaccination based on vaccine efficacy (i.e., stimulation of cellular immunity) and the development of adequate delivery options to obtain the desired reductions in seroprevalence and infection;
- Discontinuing vaccination in its implemented form if there is no indication of progress over a reasonable period;
- Implementing conservation measures to decrease mortality and increase the growth rate of the population if estimated bison abundance decreases towards 2,500;
- Altering culling or harvest strategies if significant and biologically important effects to age, genetics, herd, and/or sex structure are detected; and
- Discontinuing brucellosis containment or suppression actions if estimated bison abundance decreases below 2,500 and agency partners do not strictly implement conservation measures to abate further reductions in abundance.

MONITORING SYSTEM EVALUATION

The monitoring program will be considered successful if it provides data to: 1) evaluate progress towards achieving objectives; 2) determine resource status to identify appropriate management actions and adjust management decisions; 3) increase understanding of resource dynamics via the comparison of predictions against survey data; and 4) enhance and develop models of resource dynamics as needed and appropriate. The following questions were adapted from Williams et al. (2007) and will be considered throughout the duration of this plan to increase the likelihood of successful monitoring and evaluate progress in achieving objectives:

- Stakeholder Involvement: Are stakeholders committed to and involved in the monitoring and assessment program? Is the monitoring process able to adapt to changes in stakeholder and public viewpoints?
- Objectives: Are the monitoring objectives achievable and sustainable? Is the monitoring program providing information that can be used to track progress in meeting management objectives and better understand trade-offs among objectives?
- Management Actions: Does the monitoring plan provide information that can be used to assess the potential effects and effectiveness of the range of feasible management actions (e.g., no action, hunting, vaccination, selective culling, quarantine) and trade-offs among them? Is progress being made towards achieving management objectives? Has the set of management alternatives or implemented actions been adjusted over time based on information obtained during monitoring?
- Models: Are the hypotheses underlying the strategies for resource management expressed as testable models? Have explicit links between management actions and resource dynamics been incorporated into the models? Has the monitoring plan contributed to a better understanding of the ecological processes that drive resource dynamics? Are the relevant environmental factors incorporated into the models? Are the models calibrated with available monitoring information?
- Monitoring Plan: Does the plan support the testing of alternate models and measurement of progress towards accomplishing management objectives? Does the plan monitor the metrics necessary to estimate relevant resource and disease attributes? Have the necessary levels of accuracy been attained? Have commitments among managers, scientists, and other stakeholders been sustained during the monitoring program? Does the plan provide meaningful and useful data and information within timeframes that allow for adaptive decision making?
- Decision Making: Are decisions based on the understanding and status of the resource derived from monitoring data? Are decisions being guided by management objectives and monitoring information regarding these objectives? Are stakeholders informed and given the opportunity to comment before decisions are made or changed?
- Follow-up Monitoring: Are analysis needs understood and being met? Is monitoring conducted on a timely basis? Is monitoring targeted to system attributes that are useful for evaluation and learning? Are monitoring data collected and managed so they are available and easy to access? Can the monitoring data be used to update measures of model confidence?
- Assessment: Have monitoring data been used to evaluate the expected effects of alternate management strategies and update predictions? Have changes in management been implemented when monitoring data indicate management objectives are or are not being met?
- Iteration: Are management actions and decisions reviewed frequently based on monitoring and assessment information? Have resource management alternatives been revisited or modified over time? Has uncertainty related to resource and disease dynamics and the effects of management actions been reduced through monitoring and learning over time? Are the monitoring objectives likely to be achieved within specified or reasonable timeframes?

Each year through regularly scheduled IBMP meetings, completion of the annual IBMP report, and update of this monitoring plan, we solicit review, comment, and discussion by our agency partners and key stakeholders in the refinement of objectives, design of monitoring, and assessment to build support for the legitimate process and provide a foundation for learning-based resource management. Public information staff share the results of monitoring activities with key stakeholders through timely press releases and web-mails, and reports and articles will be made available on-line at the website for the IBMP members (<www.ibmp.info>).

MONITORING FINDINGS

The following paragraphs summarize findings of monitoring and research since the plan was initiated in 2008. These findings were reported at IBMP meetings and considered by the IBMP members in developing the annual reports and recommendations for adaptive management adjustments (White et al. 2009, Zaluski et al. 2010, Canfield et al. 2011, Patterson et al. 2012).

Conservation (Preserve a Functional, Free-Ranging Bison Population)

1. Estimate the abundance, demography, and limiting factors for the overall bison population and two primary subpopulations (i.e., central and northern breeding herds).

    - Bison abundance, age and sex structure, and recruitment are estimated each summer for the central and northern breeding herds. Results are documented in an annual count report that is posted on the website for the Interagency Bison Management Plan (http://ibmp.info/library.php). A sample of 45 to 60 radio-collared bison is maintained annually to estimate distribution, group sizes, habitat use, movements, pregnancy, and survival. These findings are released periodically in published articles (see below).

    - NPS staff collaborated with colleagues at Montana State University to estimate demographic rates from 80 adult female bison in the central herd during 1995-2006 (Geremia et al. 2009).
        - Animals testing positive for exposure to brucellosis had significantly lower pregnancy rates across all age classes compared to seronegative bison.
        - Birth rates were high and consistent for seronegative animals, but lower for younger, seropositive bison. Seronegative bison that converted to seropositive while pregnant were likely to abort their 1st and 2nd pregnancies.
        - There was a pronounced decrease in survival for animals >12 years old. Also, brucellosis exposure indirectly lowered bison survival because more bison were culled over concerns about transmission to cattle when bison attempted to move to lower-elevation areas outside the park.
        - There was a significant decrease in adult female survival when the number of bison in the central herd exceeded 2,000-2,500 animals, which was exacerbated during winters with severe snow pack because more bison moved outside the park. Except during 1996-97, the vast majority of radio-marked bison culled at the north and west boundaries during 1995-2006 came from the central herd.
        - The effects of brucellosis on survival, pregnancy, and birth rates lowered the growth rate in the central herd. Population growth rates will likely increase by more than 15% if vaccination plans are implemented and successful.

    - NPS staff collaborated with colleagues at Colorado State University to synthesize available information and interpreted results of a spatially explicit model (Coughenour 2005) of the Yellowstone system (Plumb et al. 2009).

- Bison abundance has not exceeded the theoretical food-limited carrying capacity of 6,200 in Yellowstone.
- More bison migrate earlier to lower-elevation winter ranges as numbers increase and climatic factors interact with density to limit nutritional intake and foraging efficiency.
- A gradual expansion of the winter range as bison numbers increased enabled relatively constant population growth and increased food-limited carrying capacity.
- Current management actions should attempt to preserve bison migration to essential winter range areas within and adjacent to the park, while actively preventing dispersal and range expansion to outlying areas via hazing, translocations, and culls.
- A population of 2,500-4,500 bison should satisfy collective interests concerning the park's forage base, bison movement ecology, retention of genetic diversity, brucellosis risk management, and prevailing social conditions.

- NPS staff contributed to a chapter on conservation guidelines for population, genetic, and disease management of American bison for the IUCN (Gates et al. 2010).
  - Overarching principles for conserving bison were to (1) maximize the number of bison in a population (i.e., 'maximum sustainable' rather than a 'minimum viable' population size) to better retain natural variation and provide more resiliency to 'surprises' or catastrophic events, (2) support and promote 'wild' conditions and behaviors in an environment where bison are integral to community and ecosystem processes, exposed to natural selection, and active management interventions are minimized, (3) preserve genetic integrity and health by maintaining bison lineages and carefully evaluating all movements of bison between populations, and (4) conducting routine monitoring and evaluation of demographic processes, herd composition, habitat, and associated ecological processes that are central to evaluating herd health and management efficacy.

- NPS staff developed a population model using data collected from Yellowstone bison during 1970-2012 and estimated the abundance, composition, and trends of each breeding herd to evaluate the relative impacts of harvests and other types of management removals (Geremia et al. 2011a, 2012).
  - Demographic estimates were integrated with a model of bison migration (Geremia et al. (2011b) to predict the numbers of bison moving to the park boundary each winter. These tools combined long-term monitoring data with information gained from radio-collared bison to draw conclusions about future conditions of Yellowstone bison.
  - A decision-making process was developed to advise the management of population abundance and trans-boundary movements of bison. During June and early July, NPS staff conducted population counts and age and gender classifications of each breeding herd. They then used long-term weather forecasts and the models described above to predict herd abundances and compositions at the end of the upcoming winter, and the magnitude of numbers of bison migrating to park boundaries.
  - NPS staff established annual removal objectives for bison based on abundance, disease, distribution, and demographic (age, herd, sex) goals to reduce bison numbers towards an end-of-winter guideline of 3,000, while progressing towards

equal abundance in each herd and sex ratios of 50% adult males and 50% adult females in each herd.

- A variety of management tools were considered for reducing bison numbers including (1) public and treaty harvests in Montana, (2) selective culling (shipment to slaughter) at boundary capture facilities to reduce the proportion of infectious bison, (3) selective culling (shooting, shipment to slaughter) in Montana to prevent brucellosis transmission to nearby livestock or due to human safety or property damage concerns, (4) transfer of bison to American Indian tribes or other organizations for quarantine and eventual release, and (5) transfer bison to research facilities.

- NPS collaborated with Syracuse University (Dr. Douglas Frank) during 2011-2012 to quantify forage production and consumption at six study sites across the northern grasslands in Yellowstone National Park. Five or six grazing exclosures were deployed at each site. Production and percent consumption estimates were made monthly from May to September. Data collection will continue in 2013. During the 1980s and 1990s, migratory ungulates on the northern grassland of Yellowstone had tight biogeochemical linkages with plants and soil microbes that doubled the rate of net nitrogen mineralization, stimulated aboveground production by as much as 43%, and stimulated belowground productivity by 35% (Frank and McNaughton 1993). These biogeochemical linkages were largely driven by high densities of elk that deposited large quantities of nitrogen, phosphorus, and other nutrients via dung and urine. However, rates of ungulate grazing intensity and grassland nitrogen mineralization were reduced by 25-53% by 1999-2001, partially as a result of 60% fewer elk. Since 2002, bison numbers in northern Yellowstone have more than tripled from 813 to 2,600. Larger groups of grazing bison could potentially have quite different effects than elk on nutrient redistribution and cycling on northern Yellowstone grasslands. This project should help elucidate the influence of recent changes in elk and bison numbers and distributions on ecosystem processes such as the spatial pattern and intensity of ungulate grazing and grassland energy and nutrient dynamics.

2. Describe migratory and dispersal movements by bison at a variety of temporal and spatial scales in and outside the park.

   - NPS staff collaborated with colleagues at Montana State University to quantify annual variations in the magnitude and timing of migration by central herd bison during 1971-2006 and identify potential factors driving this variation (Bruggeman et al. 2009c).
     - Bison from the central herd were partially migratory, with a portion of the animals migrating to the lower-elevation Madison headwaters area during winter while some remained year-round in or near the Hayden and Pelican valleys.
     - There was significant bison migration to the Madison headwaters area before the Hayden and Pelican valleys were fully occupied and abundance approached the food-limiting carrying capacity of these valleys.
     - After the central herd exceeded 2,350 animals, however, the number of bison wintering in the Hayden and Pelican valleys appeared to stabilize, while bison continued to migrate to the Madison headwaters area. Also, more bison migrated earlier as density increased.

- Some bison migrated outside the west-central portion of the park between the summer and winter counts each year when the central herd exceeded 2,350 bison, perhaps relocating to northern range.
- The timing and magnitude of bison migration were accentuated during years of severe snow pack that limited access to food.

- NPS staff collaborated with colleagues at Montana State University to quantify how snow, topography, habitat attributes, and roads influenced the travel patterns and non-traveling activities of 30 radio-marked, adult, female bison from the central herd during three winters (Bruggeman et al. 2009a, b).
    - Bison were less likely to use a point on the landscape for traveling or feeding as snow pack increased. However, bison used local areas with deeper snow as the overall snow pack increased on the landscape.
    - Distance to stream was the most influential habitat covariate, with the spatial travel network of bison being largely defined by streams connecting foraging areas. Distances to foraging areas and streams also significantly influenced non-traveling activities, being negatively correlated with the odds of bison foraging or resting.
    - Topography significantly affected bison travel patterns, with the probability of travel being higher in areas of variable topography that constrained movements (e.g., canyons). Distance to road had a significant, negative effect on bison travel, but was nine times less influential compared to the impact of streams.
    - Road grooming has a minimal influence on bison travel and habitat use given the importance of natural dynamic and static landscape characteristics such as snow pack, topography, and habitat attributes on bison choice of travel routes and habitat use for foraging and resting.

- NPS staff collaborated with staff from Colorado State University to analyze the relationships between bison population size, winter severity, and the number of bison removed near the boundary of Yellowstone during 1990-2010 (Geremia et al. 2011b).
    - Migration differed at the scale of herds, but a single unifying exponential model was useful for predicting migrations by both herds.
    - Migration beyond the northern park boundary was affected by herd size, accumulated snow water equivalent, and aboveground dry biomass. Migration beyond the western park boundary was less influenced by these predictors, and model predictions since 2006 suggest additional drivers (e.g., learning) of migration were not in the model.
    - Simulations of migrations over the next decade suggest that a strategy of sliding tolerance where more bison are allowed beyond park boundaries during severe climate conditions may be the only means of avoiding episodic, large-scale reductions to the Yellowstone bison population in the foreseeable future.

3. Estimate the existing heterozygosity, allelic diversity, and long-term probabilities of genetic conservation for the overall bison population and identified subpopulations.

- NPS staff collaborated with colleagues at the University of Montana to test the hypothesis that bison from the central and northern breeding herds would be genetically differentiated based on mitochondrial and microsatellite DNA from fecal samples.

- Based on mitochondrial DNA analyses, there was significant genetic differentiation between bison sampled from the northern and central breeding herds, likely due to strong female fidelity to breeding areas (Gardipee 2007).

- NPS staff provided information to the Department of Interior for review by scientists from government agencies and non-governmental organizations with professional population geneticists and the development of guidance for the genetic management of federal bison populations (Dratch and Gogan 2010).
  - Parks and refuges that currently have bison populations, with the exception of Yellowstone National Park, do not have enough land to support a population of more than 1,000 bison (i.e., minimum target to preserve genetic variation over centuries).
  - Yellowstone bison have relatively high allelic richness and heterozygosity compared to other populations managed by the Department of Interior.
  - Yellowstone bison are the only population with no molecular evidence (i.e., microsatellite markers) or suggestion (i.e., SNPs) of potential cattle ancestry (i.e., introgression of cattle genes). Thus, this population constitutes a genetic resource that must be protected from inadvertent introgression.
  - The Yellowstone and Wind Cave bison populations are genetically unique and the lineages are not represented elsewhere within populations managed by the Department of Interior. Thus, high priority should be given to replicating these significant lineages via satellite herd establishment (Halbert and Derr 2008).

- The NPS reviewed a study by Pringle (2011) that concluded that some Yellowstone bison have deleterious genetic mutations and, as a result, "are predicted significantly impaired in aerobic capacity, disrupting highly evolved cold tolerance, winter feeding behaviors, escape from predators and competition for breeding."
  - Bison with haplotype 6 in their mitochondrial genome carry a double mutation that affects two genes: cytochrome b and ATP6. These bison are primarily found in the central breeding herd based on recent genetic sampling. This inherited mutation could affect their production of energy (i.e., ATP produced by mitochondrial oxidative phosphorylation). Bison with haplotype 8 in their mitochondrial genome do not carry the double mutation and are primarily found in the northern breeding herd.
  - Even if the genetic sequences and analyses reported by Pringle (2011) are correct, genetic mutation does not automatically equal genetic disease. There are multiple compensating mechanisms in biological systems that combine to overcome theoretical metabolic deficiencies.
  - Also, there is direct evidence that even if Yellowstone bison have some sort of genetic deficiency, it has not been manifested through any biologically significant effect on their ability to survive. Estimated annual survival rates and birth rates for adult female bison were quite high during 1995-2006; especially given the severe, prolonged, high-elevation winter conditions and predator-rich environment in and near Yellowstone National Park.
  - The NPS is taking steps to follow-up on Dr. Pringle's work and recommendations.

- NPS staff collaborated with colleagues at the University of Montana to conduct a mathematical modeling assessment that provided predictive estimates of the probability of preserving 90 and 95% of the current level of genetic diversity values (both heterozygosity and allele diversity) in Yellowstone bison (Pérez-Figueroa et al. 2012).

- Findings suggested that variation in male reproductive success had the strongest influence on the loss of genetic variation, while the number of alleles per locus also had a strong influence on the loss of allelic diversity.
- Fluctuations in population size did not substantially increase the loss of genetic variation when there were more than 3,000 bison in the population. Conservation of 95% of the current level of allelic diversity was likely during the first 100 years under most scenarios considered in the model, including moderate-to-high variations in male reproductive success, population sizes greater than 2,000 bison, and approximately five alleles per locus, regardless of whether culling strategies resulted in high or low fluctuations in abundance.
- However, a stable population abundance of about 2,000 bison was not likely to maintain 95% of initial allele diversity over 200 years, even with only moderate variation in male reproductive success. Rather, maintenance of 95% of allelic diversity is likely to be achieved with a fluctuating population size that increases to greater than 3,500 bison and averages around 3,000 bison.

- NPS staff collaborated with colleagues at University of Montana to conduct DNA extractions with fecal samples collected from Yellowstone bison in the northern and central breeding herds during 2006 and 2008.
  - Mitochondrial DNA analyses revealed two haplotypes, with higher frequency of haplotype 8 in the northern breeding herd, and significant genetic differentiation among northern and central herds ($F_{ST} = 0.40$[1]).
  - Microsatellite analyses revealed allele frequencies with low levels of subdivision between the central and northern breeding herds ($F_{ST} = 0.02$ in 2006 and 0.01 in 2008).
  - These results suggest the population has two genetically distinguishable breeding groups with strong female philopatry and male-mediated gene flow.
  - Radio-marked adult females provided evidence of female fidelity, but emigration between breeding groups was substantial during 2007-2012.
  - Staff recommended long-term monitoring of microsatellite allele and mitochondrial haplotype frequencies to track genetic diversity and population substructure. They expect F_{ST} values to fluctuate as the population responds to bison density in the two breeding herds, management actions (e.g., culling), and natural selection.

- In a study partially funded and supported by the NPS, Halbert et al. (2012) investigated the potential for limited gene flow across the Yellowstone bison population using blood and hair samples primarily collected from bison at the northern and western boundaries of the park during the winter migration period, well after the breeding season.

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[1] F_{ST} is the portion of total genetic variance contained in a subpopulation compared to the total genetic variance. Values can range from 0 to 1 and high F_{ST} implies considerable differentiation among subpopulations.

- Two genetically distinct and clearly defined subpopulations were identified based on both genotypic diversity and allelic distributions. Genetic cluster assignments were highly correlated with sampling locations for a subgroup of live capture individuals. Furthermore, a comparison of the cluster assignments to the two principle winter cull sites revealed critical differences in migration patterns across years.
- The two Yellowstone subpopulations displayed levels of differentiation that are only slightly less than that between populations which have been geographically and reproductively isolated for over 40 years.
- The authors suggested that the continued practice of culling bison without regard to possible subpopulation structure has the potentially negative long-term consequences of reducing genetic diversity and permanently changing the genetic constitution within subpopulations and across the Yellowstone population.

- NPS staff (White and Wallen 2012) disputed some of the assumptions and inferences made by Halbert et al. (2012) and suggested that human manipulation had created and maintained much of the observed population subdivision and genetic differentiation.
  - Extensive monitoring of the movements and productivity of radio-collared bison since 2005, when the population reached an abundance of approximately 5,000 bison, suggests that emigration and gene flow is now much higher than suggested by Halbert et al. (2012). Allowing the bison to migrate and disperse between breeding herds would be in the best interest of the bison population for the long term.
  - The NPS continues to allow ecological processes such as natural selection, migration, and dispersal to prevail and influence how population and genetic substructure is maintained in the future rather than actively managing to perpetuate an artificially created substructure. The existing population and genetic substructure may be sustained over time through natural selection or it may not.

4. Promote cooperative conservation in bison management by partnering with states, tribes, and others interested in bison health and recovery.

- During 2005 through 2008, 213 Yellowstone bison calves that tested negative for brucellosis exposure were transferred from the NPS to the Animal Plant Health Inspection Service and Montana Fish, Wildlife, and Parks. These bison were moved to a research quarantine facility north of Yellowstone National Park to evaluate if they would remain free of brucellosis through at least their first pregnancy and calving.
  - The quarantine feasibility study (2005 through 2011) was successful and the surviving original bison and their offspring are considered brucellosis-free by the State of Montana and APHIS. The State of Montana completed environmental compliance to relocate 87 of these bison to the Green Ranch owned by Turner Enterprises Inc. in February 2010 and the remaining 61 bison to the Fort Peck Indian Reservation in Montana in March 2012. Pursuant to memoranda of understanding, these bison are undergoing five additional years of assurance testing to increase public and scientific confidence that the bison are truly brucellosis-free.
  - In September 2012, there were 190 bison at the Green Ranch in Montana, including the surviving original bison and their offspring. All of these bison remain the property of the State of Montana until February 2015, at which time Turner Enterprises Inc. will return to Montana Fish, Wildlife, and Parks all the surviving

original bison from the quarantine feasibility study and 25% of their offspring. At that time, Turner Enterprises Inc. will gain ownership of the remaining offspring.
  - In September 2012, there were 72 bison at the Fort Peck Indian Reservation. Thirty-one of these bison were supposed to be transferred this summer to the Fort Belknap Indian Reservation in Montana. However, a Montana judge granted an injunction blocking further relocation of the bison. Per agreement, up to 25% of the progeny of these bison will be made available to the State of Montana.

- In September 2012, the Superintendent of Yellowstone National Park signed an agreement with the InterTribal Buffalo Council for occasionally transferring some Yellowstone bison to them for transport to slaughter and subsequent distribution of bison meat and other parts to American Indian tribes.

- During October 2012, staff at Yellowstone National Park consulted with members of American Indian tribes associated with Yellowstone National Park during two conference phone calls regarding the management of Yellowstone bison and possible transfers of bison to the tribes.

- Staff at Yellowstone National Park worked with the other IBMP members to develop a protocol in November 2012 that describes procedures and responsibilities for future transfers of Yellowstone bison to (1) approved slaughter facilities and subsequent consumption, (2) terminal pastures from which bison would be harvested within 120 days, and (3) operational quarantine facilities.

- In November 2012, staff at Yellowstone National Park developed a proposal for the Director of the NPS to consider establishing an operational quarantine facility that can eventually hold up to 1,000 bison and transferring approximately 250 Yellowstone bison testing negative for brucellosis exposure to the facility for several years. Bison that successfully complete the quarantine requirements would be considered brucellosis-free and could be used for conservation and/or to support the culture and nutrition of American Indian tribes.

<u>Risk Management (Prevent Brucellosis Transmission from Bison to Livestock)</u>

5. Estimate the probabilities (i.e., risks) of brucellosis transmission among bison, cattle, and elk, and the elk feed grounds in Wyoming and northern Yellowstone.

- NPS staff collaborated with colleagues at the Agricultural Research Service and University of Montana to genotype 10 variable number of tandem repeat DNA loci in 58 *Brucella abortus* isolates from bison, elk, and cattle and test which wildlife species was the likely origin of recent outbreaks of brucellosis in cattle in the greater Yellowstone area (Beja-Pereira et al. 2009).
  - Findings suggested that isolates from cattle and elk were nearly identical, but highly divergent from bison isolates. Thus, elk, not bison, were the reservoir species of origin for these cattle infections.

- NPS staff collaborated with colleagues at the U.S. Geological Survey and other agencies and universities to assess several plausible hypotheses for observed increases in the seroprevalence of brucellosis in several free-ranging elk populations of Wyoming (Cross et al. 2009).

- o Free-ranging elk appear to be a maintenance host for *Brucella abortus* in some areas.
- o Brucellosis seroprevalence in free-ranging elk increased from 0-7% in 1991-1992 to 8-20% in 2006-2007 in four herd units not associated with feed grounds.
- o These seroprevalence levels, which are comparable to units where elk are aggregated on feed grounds, are unlikely to be sustained by dispersal of elk from feeding areas with high seroprevalence or an older age structure.
- o The rate of seroprevalence increase was related to the population size and density of each herd unit. Enhanced elk-to-elk transmission in free-ranging populations may be occurring due to larger winter elk aggregations.
- o Elk populations inside and outside of the greater Yellowstone area that traditionally did not maintain brucellosis may now be at-risk due to recent population increases. In particular, some neighboring populations of Montana elk were 5-9 times larger in 2007 than in the 1970's with some aggregations comparable to the Wyoming feed ground populations.

- NPS staff continued collaborating with colleagues at Colorado State University to develop a Bayesian state space model to guide adaptive management of the Yellowstone bison population by assimilating data from ongoing population monitoring and designed studies of population processes (Hobbs et al. 2013). The model will be used to evaluate: 1) support in the data for frequency-dependent (i.e., population expands as bison numbers increase) versus density-dependent brucellosis transmission (i.e., area used by a population is fixed); 2) the average continuous rate of brucellosis transmission and the basic reproductive ratio (i.e., number of new infectious individuals created by a single infectious individual); 3) population growth in the presence of brucellosis; 4) seroprevalence and infection rates of adult females; 5) the probability that a susceptible bison would become infected via horizontal and vertical transmission; and 6) the relative effects of various management alternatives compared to no action.
- The NPS reviewed and provided comments on a draft of the Kilpatrick et al. (2009) article that used a model to integrate epidemiological and ecological data to quantify and assess the spatiotemporal relative risk of transmission of *Brucella* from bison to cattle outside Yellowstone under different scenarios.
  - o The risk of transmission of brucellosis from bison to cattle is likely to be a relatively rare event, even under a 'no plan' (no management of bison) strategy.
  - o The risk of transmission of brucellosis from bison to cattle will increase with increasing bison numbers and severe snow fall or thawing and freezing events.
  - o As the area bison occupy outside Yellowstone in the winter is enlarged and overlaps cattle grazing locations, the risk of transmission will increase. Thus, adaptive management measures to minimize risk of transmission will be most effective.
  - o Risk of transmission could be effectively managed with lower costs, but land use issues and the larger question of bison population management and movement outside the park might hinder the prospect of solutions that will please all stakeholders.

- NPS staff estimated the timing and location of parturition events that may have shed tissues infected by *Brucella abortus* during April to mid-June, 2004-2007 (Jones et al. 2010).

- Observed abortions occurred from January through 19 May, while peak calving (80% of births) occurred from 25 April to 26 May, and calving was finished by 5 June.
- Observed parturition events occurred in the park and on the Horse Butte peninsula in Montana, where cattle were not present at any time of the year.
- Allowing bison to occupy public lands outside the park where cattle are never present (e.g. Horse Butte peninsula) until most bison calving is completed (late May or early June) is not expected to significantly increase the risk of brucellosis transmission from bison to cattle because: 1) bison parturition is essentially completed weeks before cattle occupy nearby ranges, 2) female bison meticulously consume birthing tissues, 3) ultraviolet light and heat degrade *Brucella abortus* on tissues, vegetation and soil, 4) scavengers remove fetuses and remaining birth tissues and 5) management maintains separation between bison and cattle on nearby ranges.
- Allowing bison to occupy public lands outside the park through their calving season will help conserve bison migratory behavior and reduce stress on pregnant females and their newborn calves. The risk of brucellosis transmission to cattle can still be minimized though effective management of bison distribution.

- NPS staff collaborated with colleagues at Montana State University to analyze conditions facilitating contact between bison and elk on a shared winter range in the Madison headwaters area of Yellowstone during 1991 through 2006 (Proffitt et al. 2010).
  - Spatial overlap between bison and elk increased through winter as snow pack increased and peaked when late-term abortion events and parturition occurred for bison. Wolves contributed to immediate, short-term responses by elk that increased spatial overlap with bison, but longer-term responses to wolves resulted in elk distributions that reduced spatial overlap with bison.
  - Despite this relatively high risk of transmission, levels of elk exposure to *Brucella abortus* (2-4%) were similar to those in free-ranging elk populations that do not commingle with bison (1-3%), suggesting that *Brucella abortus* transmission from bison-to-elk under natural conditions is rare.
  - Management of brucellosis in elk populations could focus on reducing elk-to-elk transmission risk and, to the extent feasible, curtailing practices that increase elk density and group sizes during the potential abortion period.

- NPS staff collaborated with colleagues at Colorado State University to develop Bayesian models to estimate rates of incidence and routes of transmission of *Brucella abortus* bacteria among Yellowstone bison during 1995-2010 and assessed the reproductive costs (C. Geremia, National Park Service, unpublished data).
  - The median probabilities of horizontal (from unrelated bison) and vertical (from mother) exposure to calves were 0.10 (95% credible interval = 0.03, 0.22) and 0.10 (0.00, 0.28), respectively; though the distribution for vertical transmission was skewed left with most of the probability closer to zero.
  - Probabilities that adult bison were exposed to brucellosis since the preceding parturition season varied from 0.03-0.37 and snow pack severity exacerbated incidence.
  - We detected a measureable probability (0.01, 0.12) of bison recrudescing from a latent to an infectious state.

    - There was a reproductive cost of diminished birth rates following brucellosis infection, with only 59% of seropositive and recently seroconverting females with calves compared to 79% of seronegative females with calves.
    - These results suggest brucellosis is maintained through mixed transmission modes and the duration of infection may extend beyond the acute phase.

- NPS and Animal Plant and Health Inspection Service staff collaborated with colleagues at the University of California-Davis on a spatially-explicit assessment of brucellosis transmission risk among bison, elk, and cattle in the northern portion of the greater Yellowstone area (Schumaker et al. 2010).
    - Population size and winter severity were major determinants influencing bison movements to lower elevation winter grazing areas, overlapping with federally-regulated domestic cattle grazing allotments. Increasing population size resulted in higher herd densities and increased bacterial shedding.
    - Median total risk to cattle from elk and bison was 3.6 cattle-exposure event-days (95% P.I. 0.1-36.6). The estimated percentage of cattle exposure risk from the Yellowstone bison herd was small (0.0-0.3% of total risk) compared with elk which contributed 99.7-100% of the total risk.
    - Natural herd migration and boundary management operations were important in minimizing the contribution of bison to cattle exposure risk, which supports continued boundary management operations for separation between bison and cattle.
    - Transmission risks to elk from elk in other populations or from bison were very small. Minimal opportunity exists for *Brucella abortus* transmission from bison to elk under current natural conditions in the northern greater Yellowstone area.
    - Management alternatives that reduce bison seroprevalence are unlikely to substantially reduce transmission risk from elk to cattle. Strategies that decrease elk herd densities and group sizes and reduce elk-to-elk transmission could reduce the overall risk to cattle grazing in the northern portion of the greater Yellowstone area.
    - Efforts should be taken to reduce the comingling of cattle and elk, especially during the late gestation period for elk, when spontaneous elk abortions pose a risk for interspecies disease transmission.
    - Bison vaccination did not meaningfully reduce *Brucella abortus* transmission risk to cattle. Effective strategies included delaying the turn-on date to cattle grazing allotments, reducing elk seroprevalence, reducing the number of cattle at-risk, or prohibiting the comingling of elk and cattle on individual premises.

- Staff from the Montana Department of Fish, Wildlife, and Parks estimated the persistence of bacteria on fetal tissue, soil, and vegetation, and scavenging on infectious materials from birth and abortion sites near the northern and western boundaries of Yellowstone National Park during 2001-2003 (Aune et al. 2012).
    - *Brucella* bacteria can persist on fetal tissues and soil or vegetation for 21-81 days depending on month, temperature, and exposure to sunlight. Bacteria purposely applied to fetal tissues persisted longer in February than May and did not survive on tissues beyond 10 June regardless of when they were set out.
    - *Brucella abortus* field strain persisted up to 43 days on soil and vegetation at naturally contaminated bison birth or abortion sites.

  - Fetuses were scavenged by a variety of birds and mammals in areas near Yellowstone and more rapidly inside than outside the park boundary.
  - Models derived from the data determined a 0.05% chance of bacterial survival beyond 26 days (95% Credible Interval of 18-30 days) for a contamination event in May.

- The University of Montana and collaborators (including the NPS) examined transmission of *Brucella abortus* between bison, elk, and cattle using nine variable-number tandem repeat (VNTR) markers on DNA from bacterial isolates from 98 tissue samples from geographically-distinct populations of all three host species in Idaho, Montana, and Wyoming (M. O'Brien, University of Montana, unpublished data).
  - Haplotype network assessments of genetic relatedness among *Brucella* isolates suggested substantial interspecific transmission between elk and bison populations in both Wyoming and Montana.
  - *Brucella* genotypes from the 2008 cattle outbreak in Wyoming matched elk *Brucella* genotypes confirming elk as the likely source. However, *Brucella* from the two recent outbreaks (2008, 2010) in Montana cattle had genotypes similar to both bison and elk. Because wild bison have been excluded from these cattle areas, this finding suggests transmission occurred between bison and elk in Yellowstone in the past, before eventually being transmitted among elk and by elk in the Paradise Valley to cattle.
  - Identical *Brucella* genotypes among many elk populations in Montana suggests that brucellosis may have become established in Montana through intraspecific transmission among populations, without all infected elk originating as immigrants from Wyoming or by transmission from Yellowstone bison.

6. Estimate age-specific rates of bison testing seropositive and seronegative for brucellosis that are also culture positive and the portion of seropositive bison that react positively on serologic tests due to exposure to cross-reactive agents other than *Brucella abortus* (e.g., *Yersinia*).

- NPS staff collaborated with colleagues at the University of Montana to investigate if *Yersinia enterocolitica* serotype *O:9* caused false-positive reactions in brucellosis serological tests for bison using culturing techniques and multiplex PCR (See et al. 2012).
  - *Yersinia enterocolitica* was not detected in samples of feces collected from 53 Yellowstone bison culled from the population and 113 free-roaming bison from throughout the greater Yellowstone ecosystem.
  - These findings suggest *Yersinia enterocolitica O:9* cross-reactivity with *Brucella abortus* antigens is unlikely to cause false positive serology tests in bison, and that *Yersinia enterocolitica* prevalence is low in these bison.

- NPS and Animal and Plant Health Inspection Service staff sampled more than 400 bison that were consigned to slaughter during winter 2007-2008 and collected blood and tissues to estimate the proportion of seropositive and seronegative bison that were actively infected with *Brucella abortus* (i.e., culture positive; Treanor et al. 2011).
  - Removing brucellosis-infected bison is expected to reduce the level of population infection, but test and slaughter practices may instead be removing mainly recovered bison. Recovered animals could provide protection to the overall population through

the effect of population immunity (resistance), thereby reducing the spread of disease. Identifying recovered bison is difficult because serologic tests (i.e., blood tests) detect the presence of antibodies, indicating exposure, but cannot distinguish active from inactive infection.

    - Age-specific serology and *Brucella abortus* culture results from slaughtered bison were integrated to estimate probabilities of active brucellosis infection using a Bayesian framework. Infection probabilities were associated with age in young bison (0-5 years old) and with elevated antibody levels in older bison (>5 years old). Results indicate that Yellowstone bison acquire *Brucella abortus* infection early in life but typically they recover as they grow older.
    - A tool was developed to allow bison management to better reflect the probability that particular animals are infective, with the aim of conserving Yellowstone bison while reducing the risk of brucellosis transmission to cattle. Fluorescent polarization assay (FPA) values were higher in seropositive bison that were culture positive compared to seropositive bison that were culture negative, supporting that active infection is associated with increased antibody production.
    - The two covariates (age and FPA) have management application to identify the probability of active infection within specified credible intervals. This would allow for removing bison that most likely contribute to brucellosis maintenance in the population, while keeping bison that contribute to population immunity which reduces brucellosis transmission.
    - Estimation of true infection probabilities can replace culling practices (such as the slaughter of all seropositive individuals) that conflict with bison conservation. Combining selective removal of infectious bison with additional management practices, such as vaccination, has the potential to advance an effective brucellosis reduction program.

7. Estimate the timing and portion of removals from the central and northern herds each winter, including the portion of removals from each age and sex class and calf-cow pairs.

- NPS staff retrospectively evaluated if reality met expectations by comparing assumptions and predictions for the alternative selected from the Final Environmental Impact Statement and described in the Record of Decision for the IBMP (USDI and USDA, 2000a,b) with observed impacts and changes since implementation of the plan began in 2001 (White et al. 2011).
    - Intensive management near conservation area boundaries maintained separation between bison and cattle, with no transmission of brucellosis.
    - However, brucellosis prevalence in the bison population was not reduced and the management plan underestimated bison abundance, distribution, and migration, which contributed to larger risk management culls (total >3,000 bison) than anticipated.
    - Culls differentially affected breeding herds and altered gender structure, created reduced female cohorts, and temporarily dampened productivity.
    - This assessment was used to develop adaptive management adjustments to the IBMP in 2008 and similar future assessments will be essential for effective management to conserve the largest free-ranging population of this iconic native species, while reducing brucellosis transmission risk to cattle.

8. Document bison use of risk management zones outside the northern and western boundaries of Yellowstone and commingling with livestock during the likely brucellosis-induced abortion period for bison each spring.

- Annual bison use of habitat outside the northern and western boundaries of Yellowstone National Park, and any commingling with livestock, is documented in the annual reports for the Interagency Bison Management Plan (http://ibmp.info/library.php).

- NPS staff collaborated with staff from Colorado State University to develop a state-space model that integrated recent GPS observations with 22 years (1990-2012) of aerial counts to forecast monthly distributions and identify driving factors of migration (C. Geremia, National Park Service, unpublished data).
  - Wintering areas were located along decreasing elevation gradients and bison accumulated in wintering areas prior to moving to progressively lower elevation areas.
  - The importance of attributes representing changing food availability on movements suggested bison decision-making varied across spatial and temporal scales.
  - To support adaptive management of Yellowstone bison, future movements were forecasted and the appropriateness of alternative scenarios was assessed.

9. Estimate the effects of hazing or temporarily holding bison in capture pens at the boundary of Yellowstone (for spring release back into the park) on subsequent bison movements or possible habituation to feeding.

- Forty-five bison were captured during winter 2008 at the Stephens Creek capture facility and released in the spring fitted with radio transmitters. The winter movements of these bison (minus mortalities) were monitored during winters 2009 through 2012 to evaluate if the capture and feeding of bison appeared to be influencing future migration tendencies towards the park boundary. Results during these winters with snow packs ranging from mild (2012) to modest (2010) to severe (2011) suggest few bison are habituated to hay provided at the Stephens Creek capture facility and most bison do not migrate to lower elevations to seek forage until deep snow accumulates at higher elevations.

  Winter movements of radio-marked bison after release from the Stephens Creek capture facility in spring of 2008.

	Winter 2009	Winter 2010	Winter 2011	Winter 2012
Percent of marked bison returning to the Gardiner basin	12 of 40 = 30%	2 of 38 = 5%	28 of 34 = 82%	5[1,2] of 29 = 17%
Percent of marked bison returning to the Blacktail Deer Plateau, but not migrating as far as the Gardiner basin	16 of 40 = 40%	12 of 38 = 32%	5 of 34 = 15%	18 of 29 = 62%
Percent of marked bison that remained on interior ranges of the park	10 of 40 = 25%	20/38 = 53%	0 of 34 = 0%	6 of 29 = 21%
Percent of marked bison that	2 of 40 = 5%	4/38 = 11%	1 of 34 = 3%	3[1] of 29 =

migrated to the west boundary of the park				10%

[1] Three of these bison first migrated to the north boundary before moving to the west boundary later in the winter and were included in both calculations.
[2] Only one of these five bison moved as far north as the Stephens Creek facility during this winter period.

Brucellosis Suppression (Reduce Disease Prevalence)

10. Determine the strength and duration of the immune response in bison following hand-syringe delivery vaccination for brucellosis.

- Through the Civilian Research and Development Foundation, the NPS provided cooperative funding to key Russian vaccinologists to develop the first comprehensive review of scientific laboratory and field studies on the primary Russian brucellosis vaccine derived from *Brucella abortus* strain 82 (SR82), and publish this report in an English language peer-reviewed scientific journal (Olsen et al. 2010, Ivanov et al. 2011).
    - The smooth-rough strain SR82 vaccine combines the desired weak responses on standard tests with high efficacy against brucellosis.
    - In 1974, prior to widespread use of strain SR82 vaccine, 5,300+ cattle herds were known to be infected with *Brucella abortus* across the former Soviet Union.
    - By January 2008, only 68 cattle herds in 18 regions were known to be infected, and strain SR82 continues to be the most widely and successfully used vaccine in many regions of the Russian Federation.

- NPS staff collaborated with colleagues from the Animal and Plant Health Inspection Service and Montana State University to measure the cell-mediated immune responses (CMI) induced by SRB51 vaccination in bison (Treanor 2012).
    - During winter 2008-2009, 12 yearling bison in the quarantine feasibility study were vaccinated by syringe with SRB51. Immune responses were assessed prior to vaccination and at 3, 8, 12, 18, and 21 weeks after vaccination.
    - Additionally, 20 wild, yearling, female bison were captured at the Stephens Creek facility during late winter 2008 and 14 of these bison were vaccinated by syringe with SRB51, while six served as non-vaccinated controls. The CMI response of the vaccinated bison was analyzed at 2 and 6 weeks post vaccination. Thereafter, all 20 bison were released back into the wild during May 2008. During autumn and winter 2008-2009, 14 of the 20 bison in the study were recaptured to measure cell-mediated immune responses 24+ weeks following vaccination.
    - Comparison of the immune responses following vaccination with *Brucella abortus* strain RB51 in captive and free-ranging bison indicated a single vaccination of SRB51 may offer some protection in approximately 50% of vaccinated yearling female bison.
    - Overall, immune responses following vaccination were similar between both study groups, including the proportion of individuals within each study group that showed either strong, weak, or essentially no response following vaccination. This individual variation is expected to reduce vaccine efficacy when vaccination is applied at the population level.
    - Factors such as seasonal food restriction and loss of body reserves may play an important role in the effectiveness of wildlife vaccination programs. Protective

immune responses induced through vaccination may be limited if vaccines are delivered to undernourished animals.

11. Determine the strength and duration of immune response in bison following remote delivery (e.g. bio-bullet) vaccination for brucellosis.

- Olsen et al. (2006) reported the ballistic inoculation of bison with biobullets containing photopolymerized, polyethylene glycol-based hydrogels with SRB51 induced a significant cell-mediated immune response similar to hand-syringe injection of the vaccine. However, the immunologic responses of bison to hydrogel vaccination with SRB51 during 2007 indicated poor proliferation and interferon response compared to syringe injection (S. Olsen, unpublished data). These findings suggest the measured immune responses to vaccination are variable or there may be consistency issues with vaccine hydrogel formulation and/or encapsulation in biobullets.

- During 2003-2005, NPS staff collaborated with Colorado State University and the Agricultural Research Service to develop procedures for vaccine encapsulation and maintaining the structural consistency of projectiles. This effort demonstrated successful proof-of-concept for delivering a degradable ballistic brucellosis live vaccine remotely to bison from a distance of 40 meters using commercial components and a novel hydrogel vaccine carrier (Christie et al. 2006).

- A second vaccination trial on bison conducted using a photopolymerized SRB51 vaccine payload manufactured at the Agricultural Research Service lab in Ames, Iowa during 2007 indicated poor immunologic proliferation and interferon response compared to hand-syringe injection (S. Olsen, Agricultural Research Service, unpublished data). Results also demonstrated biobullet failure with projectiles fracturing or being too soft to penetrate the skin of vaccinated bison. These inconsistencies between studies regarding the cell-mediated immune responses observed following hydrogel vaccination of bison with SRB51 may have been due to differences in the photopolymerization process used to encapsulate vaccine in projectiles.

- NPS staff collaborated with the University of Utah and the Agricultural Research Service to develop a protocol for pursuing minor enhancements to the vaccine payload performance and the ballistic delivery system under quality controlled production prior to field test on bison. It will also involve (1) negotiating supply agreements with various reagent vendors, (2) developing scientific and technical protocols to facilitate technology transfer to a contractor who can procure and produce the entire vaccine component line, (3) initiation and supervision of a production program for biobullet vaccine formulations under quality systems validation, and (4) final delivery of ready-to-use biobullet vaccine formulations and protocols for field use (Grainger 2011).

12. Document long-term trends in the prevalence of brucellosis in bison, and the underpinning effects of remote and/or hand-syringe vaccination, other risk management actions (e.g., harvest, culling), and prevailing ecological conditions (e.g. winter-kill, predation) on these trends.

- During 2007-2009, NPS staff developed a fully functional wildlife health laboratory in the basement of the Heritage and Research Center for the processing of biological samples and the direct or indirect measurement of disease organisms, immunological indicators, or indicators associated with animal health (e.g., metabolites and hormones).
    - This laboratory enables NPS staff to maintain sample quality, get timely results, and increase sample sizes. Equipment has been used to culture cells to measure immune responses of brucellosis vaccination in bison and conduct fluorescence polarization immunoassays of serological samples for the diagnosis of brucellosis exposure.
    - The laboratory is certified as a biosafety level 2 facility, which is important for brucellosis vaccination work, but no work is conducted directly on zoonotic disease agents (e.g., *Brucella abortus*).

- NPS staff collaborated with colleagues at the U.S. Geological Survey and Montana State University to estimate how much time (years) it takes to detect a change in seroprevalence in bison over time using three analytical approaches: the single year estimate, the 3-year running average, and regression using all years to date (Ebinger and Cross 2008).
    - Capture and sampling of more than 200 bison during a given year would be necessary to detect significant changes in seroprevalence following vaccination, and detection would likely take 5-20 years depending on sample sizes and detection method.
    - 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. The ranges of possibility for the amount of decrease in seroprevalence and for the shape of the decrease curve are relatively unknown.
    - The single-year estimate approach consistently showed more variation around the median. The regression model tended to be a more powerful approach, though there was 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.
    - 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. 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.

- NPS staff collaborated with colleagues at the University of Kentucky to develop an individual-based model to evaluate how brucellosis infection might respond under alternate vaccination strategies, 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; and 3) vaccinating all female bison (including adults) during boundary capture and throughout the park using remote delivery of vaccine (Treanor et al. 2007a,b; 2008, 2010).

- Simulations suggested Alternative 3 would be most effective, with brucellosis seroprevalence decreasing by 66% (from 0.47 to 0.16) over a 30-year period resulting from 29% of the population receiving protection through vaccination.
- Under this alternative, bison would receive multiple vaccinations that extend the duration of vaccine protection and defend against recurring infection in latently infected animals.
- The initial decrease in population seroprevalence will likely be slow due to high initial seroprevalence (40–60%), long-lived antibodies, and the culling of some vaccinated bison that were subsequently exposed to field strain *Brucella* and reacted positively on serologic tests.
- Vaccination is unlikely to eradicate *Brucella abortus* from Yellowstone bison, but could be an effective tool for reducing the level of infection.

- NPS staff collaborated with colleagues at the U.S. Geological Survey and Montana State University to use an individually-based epidemiological model to assess the relative efficacies of three management interventions (sterilization, vaccination, and test-and-remove; Ebinger et al. 2011).
  - Sterilization and test-and-remove were most successful at reducing seroprevalence when they were targeted at young seropositive animals, which are the most likely age and sex category to be infectious. Sterilization and test-and-remove, however, also required the most effort to implement. Vaccination was less effective, but also required less effort to implement.
  - For the treatment efforts we explored (50-100 females per year), sterilization had little impact on the bison population growth rate when selectively applied and the population growth rate usually increased by year 25 due to the reduced number of disease-induced abortions.
  - Initial declines in seroprevalence followed by rapid increases occurred in 3-13% of simulations with sterilization and test-and-remove, but not vaccination. We believe this is due to the interaction of super-spreading events and the loss of population immunity in the later stages of control efforts.
  - Vaccination reduces seroprevalence while maintaining population-immunity and minimizing the occurrence of super-spreading events. Sterilization and test-and-remove reduce population-immunity and super-spreading events become more common as the population becomes more susceptible.
  - Sterilization provided a mechanism for achieving large disease reductions while simultaneously limiting population growth, which may be advantageous in some management scenarios. However, the field effort required to find the small segment of the population that is infectious rather than susceptible or recovered will likely limit the utility of this approach in many free-ranging wildlife populations.

- NPS staff prepared a Draft Environmental Impact Statement to decide whether or not to proceed with implementation of remote delivery vaccination of bison in the park. Three alternatives were included in the document (USDI, NPS 2010a):
  - The no action alternative described the current vaccination program that is intermittently implemented at the Stephens Creek capture facility in concert with capture operations. The second alternative would include a combination of the capture program at Stephens Creek and a remote delivery vaccination strategy that would focus exclusively on young, non-pregnant bison of both sexes. Remote

delivery vaccination could occur from March to June and mid-September to mid-January through many areas of bison distribution in the park. A third alternative would include all components of the second alternative, as well as the remote vaccination of adult females during autumn. The vaccination program is intended to lower the percentage of bison susceptible to brucellosis infection.

  - The Notice of Availability for the Draft Environmental Impact Statement was published in the Federal Register (75 FR 27579) on May 17, 2010. The comment period was from May 28, 2010 to September 24, 2010. Also, NPS staff conducted three public meetings to gain information from the public on the park's purpose and significance, issues, and alternatives presented in the Draft Environmental Impact Statement. These meetings were held in Bozeman, Montana on June 14, 2010, Helena, Montana on June 15, 2010, and Malta, Montana on June 16, 2010.
  - The NPS received a total of 1,644 correspondences via letters, electronic mail (email), faxes, comments from public meetings, park forms, and web forms. These correspondences were distilled into 9,410 individual comments. From this correspondence, the NPS in collaboration with Weston Solutions, Inc. identified 6,629 substantive comments, which were divided into 26 concern statements.
  - Most respondents associated with conservation constituencies opposed the remote vaccination program and recommended vaccination of cattle rather than bison. Conversely, most respondents associated with livestock groups supported vaccination. Many respondents suggested that the projected cost of park-wide remote vaccination was too expensive to justify the benefits. A few constituency groups initiated letter writing campaigns to suggest re-directing funding to purchase grazing opportunities from private landowners outside Yellowstone National Park. Many respondents disputed the scientific information presented in the draft Environmental Impact Statement or suggested that inadequate scientific information existed to justify a decision to implement remote vaccination.

- During 2012, NPS staff continued evaluations regarding whether to remotely vaccinate free-ranging bison inside Yellowstone National Park for brucellosis using a rifle-delivered bullet with a vaccine payload.
  - Several factors suggested that the implementation of remote delivery vaccination at this time may not achieve desired results (>50% reduction in prevalence) and could have unintended adverse effects to bison, other wildlife, and visitor experience.
  - This deduction was based on the inconsistent syringe delivery of vaccine to eligible bison occupying the boundary ranges, probable low efficacy of remote vaccination given highly variable immune responses in wild bison and consistency issues with vaccine encapsulation and delivery, limitations of the proposed delivery technology (distance; injuries), and potentially negative behavioral responses by bison to repeated, annual remote deliveries resulting in the avoidance of humans.
  - To develop a lasting solution, the NPS is seeking input from independent scientists regarding the feasibility and sustainability of brucellosis suppression without significantly affecting bison behavior or visitor experience. A brucellosis science workshop, co-chaired by a representative from Montana Fish, Wildlife, and Parks, is being organized for 2013 to integrate science into a brucellosis management program that considers all stakeholder perspectives.

- Release of the final Environmental Impact Statement evaluating whether to remotely vaccinate free-ranging bison inside Yellowstone National Park has been postponed until this input is received and evaluated.

- An NPS biologist published a dissertation (Treanor 2012) that reported findings on the maintenance of brucellosis in Yellowstone bison, including links to seasonal food resources, host-pathogen interaction, and life-history trade-offs.
  - Active brucellosis infection was associated with below-average nutritional condition, with the intensity of *Brucella abortus* infection being influenced by seasonal reductions in dietary protein and energy.
  - The reproductive strategy of Yellowstone bison is linked with the seasonal availability of food, which increases bison fitness but may have consequences for *Brucella abortus* infection. Seasonal food restriction may also influence the ability of vaccinated bison to recall protective immune responses when later exposed to *Brucella abortus*.
  - The rate of fat metabolism was an important factor influencing the cell-mediated immune response (interferon-γ production). Thus, individual variation and the seasonal availability of food may reduce vaccine efficacy when vaccination is applied at the population level (Treanor 2012).

Appendix F: Inconsistencies and Uncertainties

Vaccine Efficacy

Currently, there are 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 findings and recommendations from this symposium included that SRB51 vaccine offers only "moderate" protection in bison, though this level of protection was not quantified by the authors. 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 bison. Also, 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 the effectiveness of vaccine delivery before widespread application of vaccination programs in the GYE. In addition, existing brucellosis diagnostic methods that are applied to wildlife require validation; new research is needed to develop technologies such as rapid genomic diagnostic tests involving polymerase chain reaction and vaccine bio-markers.

The following paragraphs discuss the limited progress that has been made on diagnostic tests, new vaccines, or delivery technologies to date due to the lack of market incentives and funding. 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, and as a result, 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 portion of the eligible animals could potentially 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 could 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; André et al. 2006).

Vaccine Strain RB51

In bison, the vaccine SRB51 is an imperfect vaccine that does not offer much protection from *Brucella abortus* infection, but provides intermediate protection from *Brucella abortus* transmission (Olsen et al. 2003). However, *Brucella 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 *Brucella 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 (virulence or degree of intensity of the disease produced by a pathogen). This potential adaptation of *Brucella 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 *Brucella abortus* can adapt to bison immune responses induced by SRB51 will depend on the genetic variation of *Brucella abortus* in Yellowstone's wildlife and the selection pressure from SRB51.

There are natural and physiological processes that influence 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 such as bison inhabiting temperate climates at high latitudes such as 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 and, as a result, delivery of vaccine to Yellowstone bison in late winter when they are under-nourished and stressed may be less effective at inducing an effective immune response than immunization during the summer and autumn when the body is not metabolizing fat and muscle tissues (Treanor 2012). In turn, when bison are later challenged by natural exposure to *Brucella abortus*, the immune system in some animals 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 antibodies which will combat the foreign substance; Treanor 2012). 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).

Unpublished data from Steve Olsen, Agricultural Research Service, suggest the booster vaccination (extra administration of more vaccine after an earlier dose) of female bison with vaccine SRB51 makes them less likely to abort following infection and transmit shed *Brucella abortus* to non-exposed animals. Zero of 5 bison that received a second dose of vaccine 15 months later by hand-syringe injection aborted, whereas 5 of 6 unvaccinated bison aborted, and 3 of 6 bison that were vaccinated once aborted. Additional research with larger sample sizes of bison in each category is needed to substantiate these findings.

On October 25, 2008 during the 112th Meeting of the United States Animal Health Association, staff from Yellowstone National Park asked the Scientific Advisory Subcommittee on Brucellosis for responses to six focal questions 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 2008:164-166), recognizing that sufficient data is generally lacking to make specific recommendations. Subcommittee members were Drs. 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 when animals are necropsied at parturition in a standard mid-gestational challenge model. 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 *Brucella 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 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 periparturient period [time of birth]. The committee recommends that vaccination of bison be timed to provide a minimum of 12 to 14 weeks prior to anticipated dates of exposure to virulent field strains of *Brucella 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.

Experimental vaccine efficacy studies are difficult to compare with large-scale remote vaccination of bison in Yellowstone 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. NPS staff collaborated with colleagues from the Animal and Plant Health Inspection Service and Montana State University to measure the cell-mediated immune responses induced by SRB51 vaccination in bison (Treanor 2012). During winter 2008-2009, 12 yearling bison in the quarantine feasibility study were vaccinated via syringe with SRB51. Immune responses were assessed prior to vaccination and at 3, 8, 12, 18, and 21 weeks after vaccination. Also, 20 wild, yearling, female bison were captured at the Stephens Creek facility during late winter 2008 and 14 of these bison were vaccinated via syringe with SRB51, while six served as non-vaccinated controls. The cell-mediated immune responses of the vaccinated bison were analyzed at 2 and 6 weeks post vaccination. Thereafter, all 20 bison were released back into the wild during May 2008. During autumn and winter 2008-2009, 14 of the 20 bison in the study were recaptured to measure cell-mediated immune responses 24+ weeks following vaccination. Both study groups showed favorable cell-mediated immune response (proliferation of T lymphocyte subsets) to hand-syringe vaccination with SRB51 at 2-8 weeks post-vaccination near the end of the moderate 2008 winter (Treanor 2012). Cell-mediated immune responses were significantly different from pre-vaccination levels for both study groups at nearly all post-vaccination time points. However, post-vaccination cell-mediated immune responses were more variable between individuals in the free-ranging bison compared to quarantined animals (Treanor 2012).

Vaccine Strain RB51 Plus

Olsen et al. (2009) conducted clinical challenge trials on a relatively new vaccine, SRB51 plus, and characterized immunologic responses and protection against experimental challenge after vaccination of 11-month-old bison with *Brucella abortus* SRB51 or a recombinant RB51 strain (SRB51+). When compared to bison that were not vaccinated, bison vaccinated with SRB51 or SRB51+ had significantly greater antibody responses, proliferative responses, and production of interferon-γ to SRB51 after vaccination. Compared to bison vaccinated with SRB51+, bison vaccinated with SRB51 had greater protection from abortion, fetal/uterine, mammary, or maternal infection. 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 suggested the SRB51 vaccine is a currently available management tool that could be used to help reduce brucellosis in free-ranging bison.

Vaccine Strain 82

For over 30 years, a live vaccine based on *Brucella abortus* Strain 82 has been successfully applied in many regions of Russia to reduce outbreaks of cattle brucellosis. By January 2008, after taking special measures including application of the vaccine in cattle, the number of places with brucellosis was decreased to 1.3% of its 1974 level (Ivanov et al. 2011). Positive results were also achieved for application of the vaccines in other animal species (reindeer (*Rangifer tarandus*), maral (*Cervus elaphus*), yak (*Bos grunniens*), buffalo (*Bison bonasus*), and zebu (*Bos primigenius indicus*)). Through the Civilian Research and Development Foundation, the NPS provided cooperative funding to key Russian scientists to develop the first comprehensive review of scientific laboratory and field studies on Strain 82 and published this report in an English language peer-reviewed scientific journal (Ivanov et al. 2011). However, even though the data appears promising, it will likely take many years to adequately test this select agent (especially given the lack of large animal facilities for testing) and possibly gain approval for experimental use in wildlife in the United States.

DNA Vaccines

Bison vaccinated with eukaryotic DNA expression vectors encoding the *Brucella* periplasmic protein, bp26, and the chaperone protein, trigger factor, developed enhanced antibody, proliferative T cell, and interferon-gamma (IFN-c) responses upon *in vitro* restimulation (Clapp et al. 2011). These data suggest that DNA vaccination of bison may elicit strong cellular immune responses and serve as an alternative for vaccination of bison for brucellosis. However, it will likely take many years to identify and test additional vaccine candidates and possibly gain approval for experimental use in wildlife.

Remote Ballistic Delivery Methods

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). NPS staff collaborated with the University of Utah and the Agricultural Research Service to develop procedures for vaccine encapsulation and maintaining the structural consistency of projectiles. This effort demonstrated successful proof-of-concept for delivering a degradable ballistic brucellosis live vaccine remotely to bison from a distance of 40 meters using commercial components and a novel hydrogel vaccine carrier (Christie et al. 2006, Grainger 2011).

Olsen et al. (2006) assessed the efficacy of vaccine delivered ballistically via air rifle to the muscles of penned bison via biobullets containing photopolymerized, poly(ethylene glycol)-based hydrogels with SRB51 and reported significant cell-mediated immune responses compared to bison that were not vaccinated. Also, hydrogel biobullets induced greater cellular immune responses than compressed SRB51 biobullets. Bison vaccinated by syringe tended to have greater cellular immune responses compared to bison vaccinated via biobullet, suggesting that hand-syringe vaccination induces the greatest immunologic responses, while hydrogel biobullets induce greater responses than compressed RB51 biobullets.

However, a second vaccination trial on bison conducted using a photopolymerized SRB51 vaccine payload manufactured at the Agricultural Research Service lab in Ames, Iowa during 2007 indicated poor immunologic proliferation and interferon response compared to hand-syringe injection (Olsen 2008). Results also demonstrated biobullet failure with projectiles fracturing or being too soft to penetrate the skin of vaccinated bison. These inconsistencies between studies regarding the cell-mediated immune responses observed following hydrogel vaccination of bison with SRB51 may have been due to differences in the photopolymerization process used to encapsulate vaccine in projectiles.

The protocol for production of photo-encapsulated vaccine payloads appears to have rather tight quality control features. The NPS needs consistent quality vaccine encapsulated projectiles to determine whether an operational vaccine program is feasible to logistically deliver vaccine to wild bison and whether remotely delivered vaccine can impart an effective immune response when delivered to bison outside the controlled climate of the Ames, Iowa biocontainment facility. This effort will involve some minor enhancements to the vaccine payload performance and the ballistic delivery system under quality controlled production prior to field test on bison. It will also involve (1) negotiating supply agreements with various reagent vendors, (2) developing scientific and technical protocols to facilitate technology transfer to a contractor who can procure and produce the entire vaccine component line, (3) initiation and supervision of a production program for biobullet vaccine formulations under quality systems validation, and (4) final delivery of ready-to-use biobullet vaccine formulations and protocols for field use (Grainger 2011).

Alternatives to the biodegradeable projectile with photo-encapsulated vaccine payload include (1) traditional wildlife immobilization darts, (2) modern long distance darts (Ecovet™), and (3) improvised biodegradeable darts that can be loaded with liquid vaccine. New technologies for the delivery of veterinary products are limited. The development of biodegradable darts continues to be a slow process with no currently available commercial application. Biodegradable barbs on commercially available darts have been used in captive facilities to ensure complete delivery of pharmaceutical chemicals (Killian et al. 2009). The Ecodart company in the United Kingdom has designed a large (12 gauge) diameter modified conventional dart for delivery of veterinary products to wildlife. However, this product is quite new and still requires use of a large number of darts resulting in the inevitable liability of lost darts with sharp tips left on the landscape.

Brucellosis Diagnostic Methods

The IBMP indicates that the NPS will capture all bison attempting to leave the park and test them for brucellosis exposure. Test-positive bison will be sent to slaughter and all test-negative female bison except adults in the third trimester of pregnancy will be vaccinated and held for release back into the park in spring. However, these management practices could leave Yellowstone bison more vulnerable to brucellosis infection and result in an increase in population seroprevalence. Brucellosis infection in bison may be similar to infection in cattle and most infected cattle recover by clearing the infection and exhibiting life-long immunity (Ficht 2003). Collectively, these recovered animals could slow down the spread of infection within the bison population through the overall effect of population immunity, or in other words, resistance to future transmission of brucellosis (John and Samuel 2000). Any strategy aimed at reducing brucellosis infection would benefit from the identification of actively infected and recovered bison.

Currently, there is no rapid, reliable live animal test for active infection (live bacteria in tissues) of brucellosis in bison (Roberto and Newby, 2007) and standard serologic tests merely identify exposure to *Brucella abortus* by the presence of antibodies circulating in blood (Gall and Neilsen 2001). Antibodies are long lived and most test-positive bison are animals that are no longer actively infected (Rhyan et al. 2009). Removing recovered bison increases the proportion of Yellowstone bison that are susceptible to brucellosis infection, which results in higher transmission rates. Over time, the level of active infection in Yellowstone bison may increase due to greater probability of exposure to naïve animals or, in other words, susceptible bison with little to no immune protection against *Brucella abortus*. A critical need is to develop diagnostic tests that can reliably estimate the probability of active brucellosis infection based on assay results from live animals. Such assays would allow for removing bison that most likely contribute to brucellosis maintenance in the population, while keeping bison that contribute to population immunity which reduces brucellosis transmission.

Scientists at the Idaho National Engineering and Environmental Laboratory collaborated with NPS staff to develop a polymerase chain reaction assay for potentially detecting active infection of *Brucella abortus* in bison, cattle, and elk (Roberto and Newby 2007). However, laboratory testing of blood samples suggests that the assay may be inaccurate and misleading in bison for detecting *Brucella abortus* DNA and active infection, as results in bison were largely negative (no positive DNA results compared to culture results indicating infection from the same animals). Further work is needed to improve this assay for bison.

NPS and Animal and Plant Health Inspection Service staff attempted to validate existing brucellosis diagnostic methods for bison using blood and tissues sampled from more than 400 bison that were sent to domestic slaughter facilities during winter 2007-2008 (Treanor et al. 2011). Comparisons of the proportion of seropositive and seronegative bison that were actively infected with *Brucella abortus* (culture positive) suggested that the probability of active infection increased rapidly in young bison and peaked during the age of first pregnancy, consistent with Rhyan et al. (2009) who found high seroconversion (negative to positive) rates in calves and juveniles (20%) compared to adult females (10%). The highest levels of active infection prevalence (0.43) observed in untested bison shipped to slaughter were in animals approximately 2.75 years old at the time of sampling. This suggests that young bison (more than 3 years old) may be the most vulnerable age class to *Brucella abortus* infection and that young, reproductively active, seropositive female bison drive brucellosis dynamics (Treanor et al. 2011).

Active *Brucella abortus* infection appeared to decrease in bison after 3 years of age, while seroprevalence was not observed to decrease until bison were 6 years old. Similarly, the proportion of seropositive bison that were found to be culture positive decreased as age increased, with low levels of active infection prevalence after 5 years of age (Treanor et al. 2011). These results suggest bison exposed early in life may begin to recover from acute infection after their first pregnancy following seroconversion. Treanor et al. (2011) found higher values from the flourescence polarization assay for seropositive bison that were culture positive than seropositive bison that were culture negative, supporting that active infection is associated with increased antibody production. Estimates of age and assay values could be used to identify the probability of active infection within specified credible intervals, which would allow for removing bison that most likely contribute to brucellosis maintenance in the population, while protecting bison that contribute to population immunity—thereby, reducing brucellosis transmission among bison (Treanor et al. 2011).

Portion of Bison Vaccinated each Year

Young, reproductively active, seropositive females likely drive brucellosis dynamics in Yellowstone bison, but represent a small portion of the population (Treanor et al. 2010). An effective remote delivery system would vaccinate a sufficient number of individuals in the population to induce population-level immunity. By bolstering population immunity, vaccination need not treat every last individual to reduce infection as long as a sufficient proportion of individuals have been afforded protection (Ebinger et al. 2011). However, model simulations of Yellowstone bison demonstrate that the success of vaccination is dependent on vaccine efficacy and vaccination effort. Treanor et al. (2010) indicated that vaccination of females with a vaccine of intermediate efficacy (0.5) could decrease brucellosis seroprevalence by 66% (from 0.47 to 0.16) over a 30-year period if about 30% of the population received protection through vaccination. Ebinger et al. (2011) indicated that vaccination of 50-100 individuals per year (or 2.5-5% of the female population) with a vaccine that was 100% effective for 35 consecutive years could reduce seroprevalence to less than 20% while maintaining population immunity and minimizing the occurrence of transmission events that spread the disease to a large number of susceptible animals. However, there was substantial uncertainty around these estimates which, in turn, were based on uncertain assumptions regarding brucellosis transmission and vaccine delivery and efficacy.

It is important to note that these models were not intended to make accurate, precise estimates of brucellosis suppression amounts and timelines due to uncertainty in parameters used to inform the models (e.g., weather, abundance of bison, and shifts in behavior in response to management actions). When such uncertainty is included, predictive models generally show large variation in expected outcomes, with far less confidence in achieving desired conditions (Hobbs et al. 2013). Rather, the models were developed to enable direct comparisons of differences among vaccination alternatives, and necessarily were based on assumptions that were made to reduce model complexity. Assumptions by Treanor et al. (2010) included: 1) remote delivery of vaccine to free-ranging bison would provide protection equal to bison given syringe vaccinations when handled at the boundary; 2) there would be an increase in immune protection with booster vaccination; 3) all bison captured at the park boundary were tested and positive reactors (i.e., bison with antibodies indicating previous exposure to brucellosis) were removed; 4) all bison testing negative for brucellosis exposure that migrated to the boundary were vaccinated and remained protected against infection when exposed to the field strain at specified probabilities corresponding to possible vaccine efficacy; and 5) no abortions or mortality occurred due to vaccination itself (Treanor et al. 2010). Assumptions by Ebinger et al. (2011) included a bison population limited to 1,600 yearling and adult females through an annual, random removal process, and 100% efficacy and lifetime treatment effects for vaccination and contraception (i.e., sterilization). In other words, it was assumed that all treated individuals were protected from abortions and infectious live births until death, and vaccinated or sterilized individuals did not become infected and develop antibodies after contacting infectious material.

Bison Injuries and Behavioral Responses to Remote-Vaccine Delivery

A safe remote delivery system should successfully deliver vaccine through the skin to the circulatory (blood) system of bison without injury (interfering with body functions) or decreasing reproduction and survival. 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. However, relatively few necropsies have been conducted to evaluate potential injuries caused by biobullet projectiles, and some portion of the animals will likely succumb to injury due to a variety of uncontrollable features (such as the projectile severing a sensitive nerve embedded within the muscle mass of the target). In addition, an effective remote delivery system should deliver vaccine to bison without creating behavioral disturbances (avoiding use of customary locations or running long distances) to the bison population beyond the range of natural variability. However, realistic group responses of bison to remote delivery vaccination are largely unknown, and disturbances may make bison difficult to vaccinate with this method over the long term. Remote vaccination effort will be unable to compensate for vaccine efficacy if bison are difficult to vaccinate (Treanor et al. 2010).

Tolerance for Bison in Montana

Increased tolerance for bison outside Yellowstone National Park has been linked to the initiation of an in-park vaccination program through a court-supervised mediation between the IBMP partners. The IBMP was designed to adaptively progress through a series of management steps that initially tolerated only bison testing negative for brucellosis exposure on winter ranges outside Yellowstone National Park, but eventually tolerated limited numbers of untested bison on key winter ranges adjacent to the park when cattle were not present (USDI and USDA, 2000b). Under the 2000 ROD, up to 100 untested bison would be allowed to freely range in both the north and west boundary areas. However, adaptive management adjustments to the IBMP in 2005, 2006, 2008, and 2011-2012 (Clarke et al. 2005, USDI et al. 2006, 2008, 2011; Montana Fish, Wildlife & Parks and Montana Department of Livestock 2012) increased the tolerance for untested female and bull bison outside the northern and western boundaries of Yellowstone National Park in Montana beyond that identified in the ROD for the IBMP (USDI and USDA 2000b). The IBMP was adjusted in 2005 to include bison hunting as a management action outside Yellowstone National Park (Montana Fish, Wildlife & Parks and Department of Livestock 2004). This adjustment authorized untested bison on winter ranges outside the park to provide for hunting opportunities by Montana-licensed hunters and American Indians with treaty rights. The IBMP was also adjusted in 2006 to allow increased tolerance for bull bison outside the park because there is virtually no risk of them transmitting brucellosis to cattle (Lyon et al. 1995, Frey et al. 2013). In addition, adaptive adjustments to the IBMP in 2008 and 2011-2012 increased the tolerance for untested bison on Horse Butte and in the Gardiner basin areas west and north of the park, respectively (USDI et al. 2008, Montana Fish, Wildlife & Parks and Montana Department of Livestock 2012). During 2009-2013, approximately 400-700 untested bison were allowed to migrate beyond the western boundary of the park and access suitable habitat in Montana from March through May (White et al. 2009b, Zaluski et al. 2010). In addition, during 2011 and 2012 more than 200 hundred bison migrated north of the park boundary onto habitat in Montana.

Bison abundance and distribution on lands adjacent to Yellowstone can be adjusted based on evaluations of available habitat, new conservation easements or land management strategies, reduced brucellosis prevalence in bison, and new information or technology that reduces the risk of disease transmission (USDI et al. 2008). To increase tolerance for bison, Kilpatrick et al. (2009) recommended establishing a local brucellosis infection status zone for cattle in the greater Yellowstone area and testing all cattle within this area for brucellosis (with a “split status” for the remaining portions of Idaho, Montana, and Wyoming). The Animal and Plant Health Inspection Service published an interim rule that removes the provision for automatic reclassification of any Class Free State or area to a lower status if two or more herds are found to have brucellosis within a 2-year period or if a single brucellosis-affected herd is not depopulated within 60 days (USDA 2010). Also, any Class Free State or area with *Brucella abortus* in wildlife must develop and implement a brucellosis management plan to maintain Class Free status. Under this protocol, detections of brucellosis in domestic livestock within the greater Yellowstone surveillance area are dealt with on a case-by-case basis. As long as the outbreaks are investigated and contained, then state status does not change. In fact, brucellosis was detected in several domestic bison and cattle herds in Idaho, Montana, and Wyoming during 2009 to 2011, without a change in state status. Livestock producers in the designated surveillance area are reimbursed for testing and vaccination expenses by the state.

Kilpatrick et al. (2009) also recommended the cessation of cattle grazing in areas where bison leave the park in winter and compensating ranchers for lost earnings and wages. Conservation groups and government agencies have successfully used, and are still pursuing, this strategy with willing landowners (USDI et al. 2008). For example, in 2008 Montana Fish, Wildlife & Parks signed a 30-year livestock grazing restriction and bison access agreement with the Church Universal and Triumphant, Inc. to remove livestock from the Royal Teton Ranch adjacent to the north boundary of the park (Montana Fish, Wildlife & Parks 2008a,b). The NPS provided $1.5 million to Montana Fish, Wildlife & Parks to implement the initial payment for the 30-year livestock grazing agreement and bison access agreement that should allow progressively increasing numbers of bison to use habitats north of the park boundary, including portions of the Royal Teton Ranch and the Gallatin National Forest (NPS and Montana Fish, Wildlife & Parks 2008). However, further efforts are needed to identify additional habitat and conservation areas for bison in Montana, develop fencing strategies in collaboration with private landowners that raise susceptible cattle, and identify opportunities for the enhancement or creation of bison habitat in Montana to sustain bison during April and May and discourage bison movements onto private lands with cattle (USDI et al. 2008).

Despite this rulemaking and conservation agreements, there is no guarantee of continued tolerance for bison in Montana due to brucellosis persistence, political concerns, and social values (Boyd 2003). In May 2011, the Montana Sixth Judicial District Court, Park County, granted a temporary restraining order on behalf of the Park County Stockgrowers Association that enjoined the Montana Departments of Livestock and Fish, Wildlife & Parks from implementing the 2011-2012 adjustments to the Interagency Bison Management Plan that created more tolerance for bison in the Gardiner basin north of the park boundary. Also, during winters 2011 and 2013, the Montana legislature proposed several bills intended to limit the relocation of wild bison in Montana. Though the court dismissed this lawsuit in January 2013 (Montana Sixth Judicial Court, Park County 2013), and to date, these bills have not become law, collectively these actions foretell that there may be little tolerance for bison in areas of Montana not adjacent to Yellowstone, regardless of vaccination or brucellosis status.

Appendix G: Vaccination Strategies for Brucellosis in Bison

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Vaccination strategies for managing brucellosis in Yellowstone bison

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ABSTRACT

Concerns over migratory bison (*Bison bison*) at Yellowstone National Park transmitting brucellosis (*Brucella abortus*) to cattle herds on adjacent lands led to proposals for bison vaccination. We developed an individual-based model to evaluate how brucellosis infection might respond under alternate vaccination strategies, 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; and (3) vaccinating all female bison (including adults) during boundary capture and throughout the park using remote delivery of vaccine. Simulations suggested Alternative 3 would be most effective, with brucellosis seroprevalence decreasing by 66% (from 0.47 to 0.16) over a 30-year period resulting from 29% of the population receiving protection through vaccination. Under this alternative, bison would receive multiple vaccinations that extend the duration of vaccine protection and defend against recurring infection in latently infected animals. The initial decrease in population seroprevalence will likely be slow due to high initial seroprevalence (40–60%), long-lived antibodies, and the culling of some vaccinated bison that were subsequently exposed to field strain *Brucella* and reacted positively on serologic tests. Vaccination is unlikely to eradicate *B. abortus* from Yellowstone bison, but could be an effective tool for reducing the level of infection. Our approach and findings have applicability world-wide for managers dealing with intractable wildlife diseases that cross wildlife–livestock and wildlife–human interfaces and affect public health or economic well-being.

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1. Introduction

The discovery of new infectious agents and diseases transmissible to humans has raised concerns regarding free-ranging wildlife as a source of emerging human pathogens [1,2]. Humans are often indirectly exposed to wildlife pathogens through infected livestock. The crowding and mixing of wildlife with domestic livestock can increase disease prevalence and transmission potential [3,4] thereby, increasing exposure to humans. Disease transmission risk from wildlife to domestic animals and humans traditionally has resulted in control strategies that negatively impact wildlife populations. Traditional test-and-slaughter programs have been effective for managing diseased livestock but these practices may not be realistic or socially acceptable for wildlife [5,6]. An approach to wildlife disease management is needed that addresses both public health concerns and long-term wildlife conservation. Vaccination is commonly used for disease control in veterinary medicine and wildlife vaccination may offer a promising solution [7]. The success of a vaccination program is influenced by vaccine efficacy and the proportion of the population inoculated. Our ability to deliver efficacious vaccines and monitor their effectiveness is restricted in free-ranging wildlife. Additionally, we will seldom have all the information necessary to predict the effectiveness of a wildlife vaccination program, but management actions will need to move forward despite these uncertainties.

Yellowstone National Park of the western U.S. was created in 1872, and encompasses 9018 km^2 in portions of Idaho, Montana, and Wyoming, but only about 3175 km^2 of this area currently serves as principal bison habitat (Fig. 1). The successful conservation of bison (*Bison bison*) from a low of 23 animals in 1901 to a high near 5000 animals in 2005 has led to an enduring series of societal conflicts and disagreements among various publics and management agencies regarding the potential transmission of *Brucella abortus* to domestic livestock. *B. abortus*, the bacteria causing the disease bovine brucellosis, was introduced to Yellowstone bison by cattle before 1917 and approximately 40–60% of the Yellowstone bison population have been exposed [8]. Since that time, successful conservation increased the abundance of Yellowstone bison from

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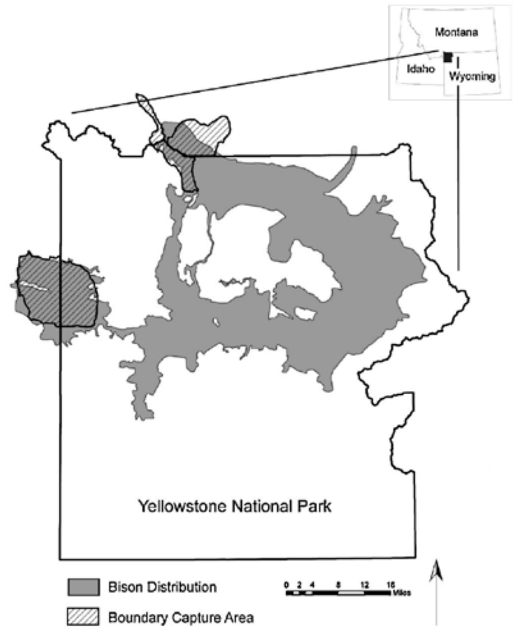

Fig. 1. Map of the distribution of bison within Yellowstone National Park and location of boundary capture areas for migrating bison. The northern and western boundary capture areas include facilities where bison are tested and vaccinated for brucellosis.

approximately 400 to >4700 in 2007 [9]. A portion of the Yellowstone bison population periodically moves between habitats in the park and adjacent lands in Montana during winter [10], resulting in a risk of brucellosis transmission from bison to cattle on overlapping ranges adjacent to the park [11]. Humans are also susceptible to infection, though brucellosis is no longer a widespread health threat in North America due to the use of sanitary procedures (e.g., pasteurization) in milk processing [12]. When livestock are infected, brucellosis results in economic loss from slaughtering infected cattle herds and imposed trade restrictions [13]. More than $3.5 billion were spent since 1934 to eradicate brucellosis in domestic livestock across the U.S. [8], however the disease remains endemic in bison (*B. bison*) and elk (*Cervus elaphus*) in the greater Yellowstone ecosystem [10]. Many livestock producers and cattle regulatory agencies contend that any risk of brucellosis transmission is unacceptable for economic and public health reasons.

To manage the risk of brucellosis transmission from Yellowstone bison to livestock, the federal government and State of Montana agreed to the Interagency Bison Management Plan [14,15]. This plan established guidelines for implementing hazing, test-and-slaughter, hunting, and other actions affecting bison abundance and distribution near the park boundary, where bison could potentially co-mingle with livestock. The plan also indicates that the National Park Service will conduct a remote delivery vaccination program of vaccination-eligible bison within the park to increase tolerance of untested bison on winter range lands outside the park. The National Park Service is currently considering the implementation of such a program to reduce brucellosis infection in the bison herd. Much remains to be learned about brucellosis epidemiology in bison and how effective vaccination may be, but it will be necessary to make decisions and proceed despite uncertainty. Simulation models can be effective tools for informing this decision-making process by evaluating the effectiveness of different management strategies. Thus, we developed an individual-based model to evaluate alternate vaccination strategies and how brucellosis infection in Yellowstone bison might respond under different approaches.

2. Model context

2.1. *B. abortus* infection

Brucellae are facultative intracellular pathogens, which evade the host's immune system by replicating within the host's white blood cells (e.g., macrophages) [16]. During middle to late gestation, Brucellae that have infected the uterus undergo massive replication in placental cells. The extensive replication causes a rupture compromising placental integrity by allowing the bacteria direct access to the fetus [17]. The resulting abortions and premature calves are highly infectious due to the large number of Brucellae on the fetus, placenta and birth fluids. Following this acute phase of infection, some bison are unable to clear the bacteria and remain infected. The pathogen's ability to establish persistent infections in some animals results in a class of latent carriers. The relapsing of latently infected animals to the infectious state during future pregnancies, is a concern with Yellowstone bison.

Intracellular protection and replication are crucial components of incubation, latency, and chronic infection of Yellowstone bison [18]. Thus, we modeled these aspects of brucellosis infection in bison by including an incubation period in the model. This allowed for deciding whether a pregnant, susceptible bison that was recently exposed would have adequate time to shed *B. abortus*. Also, we addressed latent infection in the model by assuming bison never truly recover from brucellosis and that adult females can potentially shed *B. abortus* throughout their reproductive lives.

2.2. *B. abortus* transmission

Transmission of *B. abortus* in Yellowstone bison is believed to occur primarily through contact with an aborted fetus or infected birth tissues shed during a live birth. The number of exposures that occur during these infectious events depends on the behavior of the bison cow at the time of parturition. Bison tend to give birth in close proximity to other group members, which increases the likelihood of transmission. *B. abortus* is also known to cause mammary gland infections [19] and can be transmitted through infected milk [18,20,21]. Though bacterial numbers in milk are lower than in an infected placenta, they are typically high enough to present a serious risk of transmission [8]. The role vertical transmission (transmission from cow to newborn calf) plays in the maintenance of *B. abortus* in Yellowstone bison is unclear, but may help explain the low frequency of observed abortions, high seroprevalence rates among young animals, and latent infection.

We modeled *B. abortus* transmission via infectious events (i.e., abortions and infectious live births) and vertical transmission to calves. We assumed that a proportion of latently infected adult cows will recrudesce in any given year and have an infectious live birth. Also, a proportion of calves born from these infectious births will become infected through vertical transmission.

A key component of brucellosis transmission is the number of exposures that occur during an infectious event. Thus, the ability of the *Brucella* pathogen to spread could be influenced by group size, composition, cohesion, and the infection status of associates [22]. Yellowstone bison appear to have a dynamic social structure with fluid movements between groups [23–27]. The fundamental social unit is the cow–calf association, which persists for approximately

9 months in male calves and 14 months in female calves [26,28]. There is little evidence that groups of related females form lifelong associations [23], but cows with calves tend to be found more often in groups with other cow–calf pairs [29]. Also, group sizes tend to get larger as habitat becomes more open and generally increase during the spring calving season [25].

We did not assume that every individual in the population is equally likely to become exposed to *B. abortus*. If the association among cows is not random, an individual's chance of being exposed is influenced by the infection status of its associates. We modeled the bison social group as a fluid unit where infectious events occur and the cow–calf pair as the focal unit of exposure.

2.3. *B. abortus* detection in bison

Identifying the state of brucellosis infection within the Yellowstone bison population relies on diagnostic tests performed on a segment of the bison population captured at the park boundary. Brucellosis infection is diagnosed in bison through serologic tests and bacterial cultures. For serologic tests, the fluorescent polarization assay (FPA) is the diagnostic test of choice for detecting brucellosis in bison because of its high sensitivity (94.5%), specificity (99.5%), and adaptability to field use [30–32]. Serologic tests provide indirect evidence of infection because they detect antibodies (i.e., responses to infection) rather than living bacteria and can result in both false positive and false negative diagnoses. Thus, it is unlikely that the probability of identifying truly infectious individuals can be accomplished by serology alone [8]. Combining serologic testing with tissue culture identified that nearly half (46%) of slaughtered seropositive bison were also culture positive [33]. Based on this work, we estimated that 46% of seropositive bison were culture positive animals and considered to be actively infected. We assumed, based on the use of the FPA as a diagnostic tool, that all actively infected bison and a high proportion of latent infected animals could be diagnosed as positive under boundary capture scenarios.

2.4. Vaccination of Yellowstone bison

The objective of bison vaccination is to stimulate an acquired immune response to *B. abortus* thereby increasing herd immunity and reducing the potential for transmission. The live *B. abortus* strain RB51 (SRB51) is the official brucellosis vaccine for cattle in the U.S., but has the potential to induce abortions in pregnant bison vaccinated in mid-gestation [34]. Though bison calves vaccinated with SRB51 may be safely booster-vaccinated during their first pregnancy, making early gestation a potentially safer period for vaccinating adult pregnant bison [20]. Based on these findings we developed vaccination strategies that would limit the potential for vaccine induced abortions by focusing on reproductively immature bison and adult females during early gestation.

There is uncertainty about the level of protection (i.e., efficacy) SRB51 will provide Yellowstone bison based on experimental studies. Vaccination of bison calves provided protection from abortions and placental infection when challenged with virulent *B. abortus* during their first pregnancy [22]. However, SRB51 was found to have little efficacy in adult and calf bison despite repeated vaccinations [35,36]. Thus, the duration of protection provided by a single dose of SRB51 is unknown and older cows may need to be booster-vaccinated to extend the protection of the vaccine [20]. A key feature of SRB51 is that vaccinated bison remain seronegative when tested with standard serologic tests [37] which prevents the removal of tested vaccinated animals.

Delivery of vaccine poses a problem with free-ranging bison and, currently, the most feasible method of remote vaccine delivery is via biodegradable projectiles (i.e., "bio-bullets"). Ballistic vaccination has been used to inoculate free-ranging elk on feedgrounds in Wyoming [38] and tested experimentally with bison. Ballistic inoculation of bison with photopolymerized SRB51 packaged into bio-bullets induced a significant cell-mediated immune response that was similar to syringe delivery of the vaccine (i.e., parenteral vaccination) [39]. We assume that remote delivery of SRB51 to free-ranging bison would provide protection equal to bison given syringe vaccinations when handled at the boundary. We also addressed waning immune protection in the years following vaccination and included an increase in protection with booster vaccination.

3. The individual-based model

3.1. Model development

We developed an individual-based model (IBM) using MATLAB 7 (The MathWorks, Natick, MA, U.S.A.) to evaluate the effectiveness of vaccination at reducing brucellosis infection in Yellowstone bison under the following three vaccination alternatives: (1) vaccination of female calves and yearlings captured during boundary management operations, (2) combining remote vaccination using bio-bullet delivery with boundary vaccination of female calves and yearlings, and (3) vaccinating all female bison during boundary operations and as targets for remote delivery. Under each alternative, we assumed bison captured at the park boundary were all tested and positive reactors removed.

The IBM tracked information on each female bison born into the population (Fig. 2A). The model used a yearly time step to simulate population level processes and daily time steps to simulate exposure routes during the transmission period (Fig. 2B). The yearly time step components involved mating, natural mortality, exposure to *B. abortus* via elk, and effects of management operations (testing and subsequent removal of seropositive bison at park boundaries). The daily time step detailed the processes (*Brucella* induced abortions and infectious live births) leading to shedding and transmission of *B. abortus* among Yellowstone bison. Male bison were included in yearly outputs, but were not a focal component of the model because their role in maintenance and transmission is expected to be minimal [40]. Age, sex, disease status, reproductive status, and vaccination status were recorded for each female bison modeled.

Modeled bison were initially assigned a disease status (susceptible, infected, or latent) based on estimates derived from Yellowstone bison seroprevalence data. Bison that had never been exposed to *B. abortus* were classified as susceptible. Infected bison were viewed as actively infectious and modeled to shed *B. abortus* at a high probability during their next pregnancy. These infected bison then entered a latent class with a low probability of shedding *B. abortus* during future pregnancies. Changes in the disease classes of individuals were used to predict the disease status for the overall population with population seroprevalence being the sum of infected and latent bison. Individuals changed their disease class based on events (i.e., exposure, vaccination) and rules associated with their current state (i.e., disease class, pregnancy status, vaccination status).

The model included two types of infectious events for simulating horizontal transmission: *Brucella* induced abortions and infectious live births. We assumed that both events had equal transmission potential. We also assumed that infected bison did not fully recover from the disease. These animals had a low probability of shedding the bacteria in future pregnancies while remaining latently infected. In situations where latent cows recrudesced and shed *B. abortus* during an infectious live birth, their calves became infected through vertical transmission (consuming infected milk) at a specified probability.

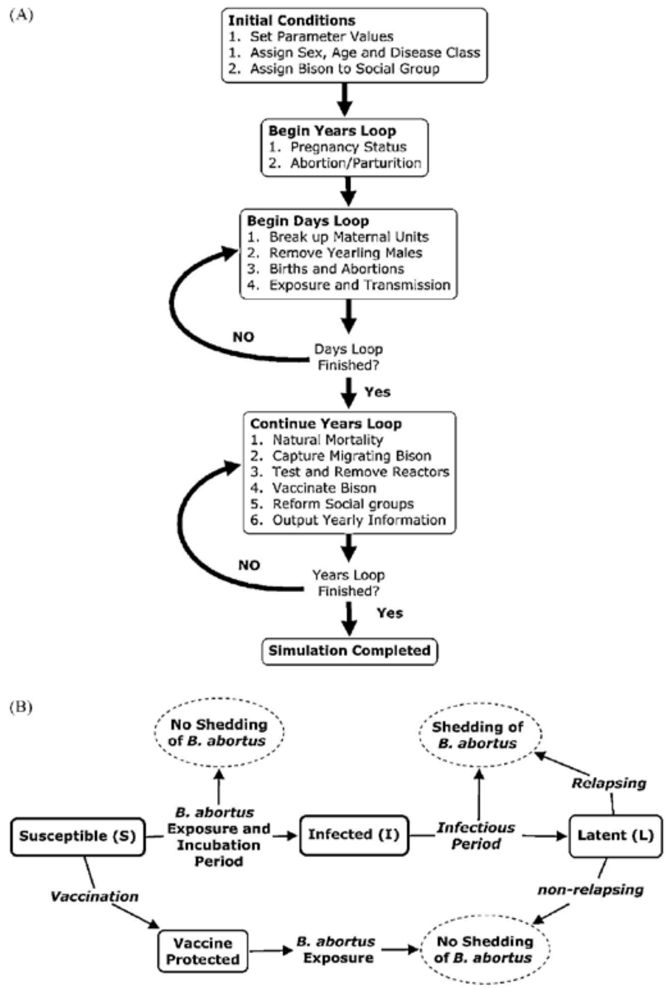

Fig. 2. Flow diagram of individual-based model processes influencing the state of *B. abortus* infection in Yellowstone bison. The sequences simulated (panel A) for the three vaccination alternatives were run for a 30-year period with yearly processes controlling population demographics and vaccination status and daily processes detailing *B. abortus* exposure and transmission. Changes in disease state and vaccination status (panel B) were based on rules of exposure and vaccine efficacy.

In the model, vaccinated, susceptible bison were classified as vaccine-protected based on the assigned efficacy of the vaccine. These bison remained vaccine-protected when exposed to the field strain at specified probabilities corresponding to vaccine efficacy. When field exposure overwhelmed the protection of the vaccine, the bison became infectious (i.e., entered the infected disease class). A vaccine delivery parameter was used for alternatives involving remote vaccination. This represented the proportion of targeted bison in the population that were likely to receive the vaccine. Once the vaccine was delivered, bison entered the vaccine-protected class based on the level of vaccine efficacy.

3.2. Model processes

Model parameters (Table 1) were initialized prior to running the model. Management options were set to simulate desired vaccination alternatives under specified levels of vaccine effectiveness. Each bison was assigned to a social group during initialization. Bison were provided with demographic information (i.e., age, sex) and assigned to a disease class based on estimates derived from seroprevalence data. Age was assigned using estimates of bison population age structure (1–15 years) and sex was assigned assuming an equal sex ratio. Bison social groups were then subdivided into maternal units, with calves assigned to mothers (i.e., cow–calf unit).

The annual time step began with bison becoming pregnant based on estimates of age-specific pregnancy rates. Pregnant bison were given either a pregnancy date or an abortion date depending on the individual's disease class. The abortion period included the last trimester (90 days) of gestation (287 days) before the live birth period (61 days). Depending on their disease status, pregnant bison had a non-infectious live birth (i.e., *Brucella* not shed;

Table 1
Default parameter values for an individual-based model predicting how brucellosis infection in Yellowstone bison might respond under alternate vaccination methods.

Parameter/variable	Value	Source
Pregnancy rate (Pr)		National Park Service
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	National Park Service
Birth period (Bdays)	61 days	[43]
Abortion period (Adays)	90 days	[8]
Death rate (Dr)		[44]
0–2 years	0.2	
3–13 years	0.1	
14 years	0.2	
15 years	1.0	
Social group size		National Park Service
Minimum	24	
Maximum	48	
Disease state		National Park Service and Montana
Susceptible (S)	0.53	Department of Livestock captures
Infected (I)	0.22	[33]
Adult latent (L)	0.25	
Rate of recrudescence	0.05	Review of latency literature
Exposures per infectious event	Poisson (λ = 1)	National Park Service
Vertical transmission	0.66	[45]
Minimum incubation	35 days	[45]
Social transmission factor (β)	1.5	Fitted parameter
Bison captures at park boundary per year		National Park Service 1985–2005
0–10% of population	0.84	
10–20% of population	0.11	
20–40% of population	0.05	
Bison removals at capture facility		
Removal of infected class	1.0	[32]
Removal of latent class	0.94	
Vaccine efficacy		Modeled over a range of values

calves classified as susceptible), an infectious live birth (i.e., *Brucella* shed; calves classified as susceptible (0.34) or infected (0.66)), or a brucellosis-induced abortion. We treated infectious material from abortions and infectious live births equally with regard to disease transmission. Susceptible bison had a non-infectious live birth unless exposed to *B. abortus* during pregnancy and there was sufficient incubation time (35 days) for *B. abortus* to be shed. If there was insufficient incubation time (<35 days) before parturition, the female did not abort or have an infectious birth. However, the female's newborn calf was infected via vertical transmission with a set probability (0.66). Bison infected with greater than 35 days of incubation prior to parturition aborted their pregnancy at a specified probability (0.96) or infected their newborn calves via vertical transmission (0.66). Pregnant, latent cows had a non-infectious birth unless they relapsed to the infectious state. We assumed 5% of latently infected adult females relapsed in a given year and shed *B. abortus* through infectious live births and infected their calves through vertical transmission.

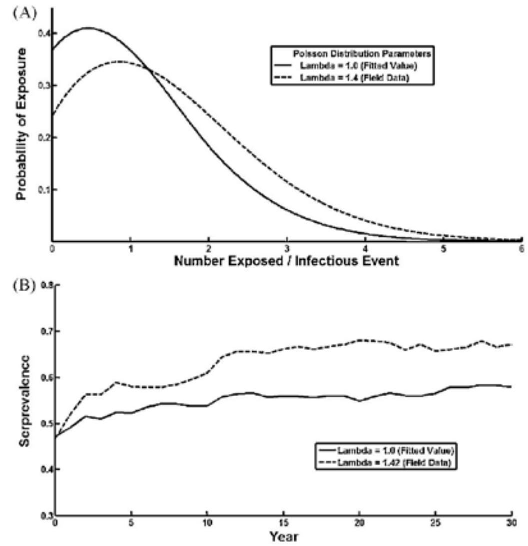

Fig. 3. Estimate of *B. abortus* transmission following an infectious event (abortion or live birth). The number of bison exposed was estimated using a probability (Poisson) distribution fit to field observations of bison making contact with newborns and expelled birth tissues (panel A). The rate parameter (lambda) for the probability of exposure was adjusted to simulate historic seroprevalence ranges (40–60%) for Yellowstone bison (panel B).

Based on field observations of bison group members interacting with newborn calves and birth tissues, we assumed cow–calf pairs approached parturition sites and were exposed to *B. abortus* together. Thus, transmission was modeled using the exposure of maternal units that were either cows and their newly born calves or single female bison (≥1-year old) to infectious events (i.e., abortions and infectious live births). Maternal units in the susceptible class became infected when exposed, while the disease status of already infected and latent class bison remained unchanged. The number of maternal units exposed per infectious event was decided by drawing from a Poisson distribution fitting field observations of Yellowstone bison licking newborns or expelled birth tissues. Contact with birth material was treated as a discrete random variable and a Poisson distribution was fit to the frequency of contacts by group members. The rate parameter that best fit the field data (λ = 1.42) was adjusted (λ = 1.0) to fit the historical population seroprevalence estimates (Fig. 3).

Long-term group size information for Yellowstone bison [23] was used to divide the population into groups of cows and their calves. Social groups of 24–48 females and calves were assumed to have greater contact with each other than with bison outside their group. Thus, the probability of exposure following an infectious event is expected to be higher within groups than among groups due to the proximity of individuals to infectious birth tissues. However, the mixing of bison social groups and the ability of *B. abortus* to persist on the landscape [41] suggests there is transmission potential to bison outside the social group experiencing the infectious event. The specific maternal units exposed were determined using a biased draw from the population, with parameter β biasing exposures in favor of bison maternal units within the social group where the infectious event occurred. The probability that an exposure will occur in any group, other than the group containing the infectious

Table 2
Annual proportions of bison captured at the boundary of Yellowstone National Park during winters 1985–2005.

Winter	Bison captured	Population count	Proportion captured
1985	88	2114	0.041
1986	57	2291	0.024
1987	6	2433	0.002
1988	35	2644	0.013
1989	569	3159	0.180
1990	4	2606	0.001
1991	14	3178	0.004
1992	271	3426	0.079
1993	79	3304	0.023
1994	5	3551	0.001
1995	427	3956	0.107
1996	433	3398	0.127
1997	1084	3436	0.315
1998	11	2105	0.005
1999	94	2239	0.041
2000	0	2444	0.000
2001	6	2800	0.002
2002	265	3286	0.080
2003	252	3880	0.064
2004	488	3824	0.127
2005	184	4239	0.043

event, was expressed using Eq (1):

Probability of outside group transmission

$$= \frac{N_i}{\beta(N_k - 1) + \sum_{\substack{j=1 \\ j \neq k}}^{n} N_j} \quad (1)$$

where N_i is the number of bison maternal units in a social group where infectious material was not shed, $(N_k - 1)$ is the number of maternal units in the social group experiencing the infectious event less the shedding maternal unit, $\sum N_j$ is the total number of maternal units in all social groups not experiencing the infectious event and beta (β) is a constant. The constant β was used to increase the probability of exposures occurring within the social group experiencing the infectious event and was expressed using Eq. (2):

Probability of within group transmission

$$= \frac{\beta(N_k - 1)}{\beta(N_k - 1) + \sum_{\substack{j=1 \\ j \neq k}}^{n} N_j} \quad (2)$$

Following the daily processes influencing transmission and exposure, the remaining annual processes were simulated. Social groups and their maternal units were reestablished based on group size criteria. Bison were subjected to natural mortality based on estimated age-specific death rates. Management operations (i.e., test, remove, vaccinate) were modeled for each of the three vaccination alternatives. The portion of the Yellowstone bison moving beyond the park boundary was modeled based on the past 20 years of capture operations. We used a frequency distribution of the portion of the population captured (<0.1, 0.1–0.2, and 0.2–0.3) at the park boundary each winter during 1985–2005 (Table 2) to estimate the number of bison that might be tested in a given year.

Seropositive bison were removed from the model to simulate management operations based on the sensitivity and specificity of the FPA serologic test. We assumed that infected and latent bison could be correctly diagnosed as seropositive during 100% and 95% of the tests, respectively. The remaining seronegative bison were vaccinated and assigned vaccine-protected status based on the specified efficacy of the vaccine. These vaccinated bison retained their vaccine-protected status if exposed to *B. abortus* based on the level of vaccine efficacy. Also, we assumed no abortions or mortality occurred due to vaccination itself. Simulations were run over a range of vaccine efficacy values under each management alternative. Vaccine-protected bison that were subsequently exposed to *B. abortus* were expected to react positively on serologic tests and, consequently, be removed during management operations. We recorded the proportion of these seropositive-vaccinates in the model under each alternative. Bison previously exposed to *B. abortus* (i.e., infected and latent bison) remained in their original states if vaccinated. We included a duration-of-protection component to vaccine efficacy, which modeled a decreasing level of vaccine protection in years following vaccination to identify the effect of waning immune protection.

Elk populations in the greater Yellowstone ecosystem are also infected by *B. abortus* and have been implicated as the source of brucellosis infection to cattle herds in Idaho, Montana, and Wyoming [42]. The pathology of the disease in elk is believed to be similar to bison and cattle. We included elk as a potential source of brucellosis infection for bison and modeled exposure from elk to bison at a low probability (0.01).

The annual processes concluded by outputting all relevant information for each year. The data were then analyzed over a 30-year period and comparisons were made between the three vaccination alternatives. The rate of decrease in population seroprevalence and the corresponding proportion of the population vaccinated were used to assess the effectiveness of each vaccination alternative. Each vaccination alternative was evaluated by running multiple model simulations over a range of vaccine efficacy and delivery parameters.

4. Results

We conducted 10 simulations at intermediate levels of vaccine efficacy (0.5) for each of the three vaccination alternatives: (1) boundary vaccination of female calves and yearlings; (2) combination of boundary and remote vaccination of female calves and yearlings; and (3) boundary and remote vaccination of all females. Under Alternative 1, seroprevalence decreased by 24% from 0.46 to 0.35 over the 30-year period, with 1% of the population vaccinated. Under Alternative 2, seroprevalence decreased by 40% from 0.47 to 0.28 over the 30-year period, with 10% of the population vaccinated. Under Alternative 3, seroprevalence decreased by 66% from 0.47 to 0.16 over the 30-year period, with 29% of the population vaccinated. Thus, combining boundary and remote vaccination of all female bison (Alternative 3) resulted in the greatest seroprevalence decreases over the 30-year simulation period (Fig. 4A).

Alternative 3 resulted in a larger proportion of vaccine-protected bison compared to the other two alternatives (Fig. 4B), and the relationship between seroprevalence and the proportion of the bison population vaccinated over the 30-year period was $y = 2.4x + 0.85$ ($R = 0.92$). Boundary removals resulting from migrations out of the park were stochastic, but there was a reduction of seropositive bison removed at the boundary as the level of vaccine-protected bison increased in the population. The proportion of seropositive-vaccinates (i.e., vaccinated bison that were subsequently exposed to *B. abortus*) was larger under Alternative 3 than Alternatives 1 and 2. Population growth rates increased from $\lambda = 1.02$ (Alternative 1) to $\lambda = 1.05$ (Alternative 3) with greater vaccination effort.

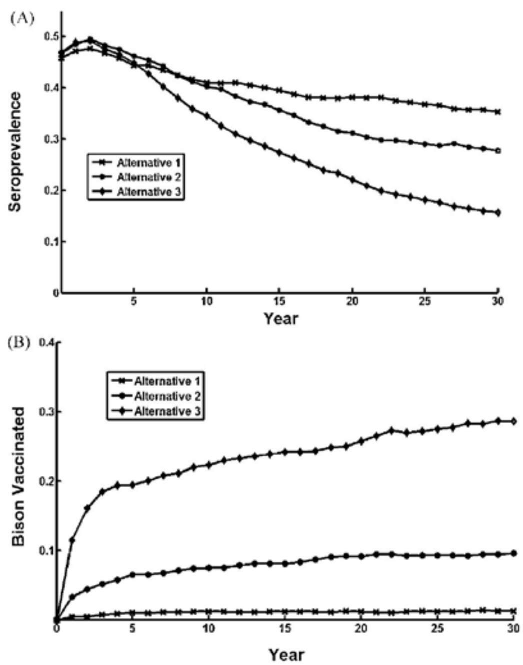

Fig. 4. Simulated declines in brucellosis seroprevalence (panel A) and the proportion of the bison population vaccinated (panel B) for each of the vaccination alternatives.

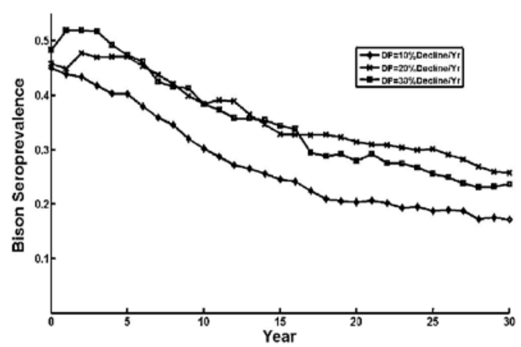

Fig. 5. Simulated declines in seroprevalence for Alternative 3 with waning vaccine protection. Line markers correspond to decreasing vaccine protection (based on the initial vaccine efficacy of 0.5) each year. The initial level of protection was restored if bison were re-vaccinated.

Simulations indicated the effect of decreasing levels of vaccine efficacy (0.10, 0.20, and 0.30 per year) on seroprevalence had the most pronounced effect on Alternative 3 (i.e., the alternative with the most remote vaccination effort, Fig. 5), while model trajectories were more variable in the other two alternatives with less vaccination effort. Exploratory simulations to better understand the response of infection under a short-term (10 years) implementation of Alternative 3, after which all vaccination and management activities ceased, indicated seroprevalence returned to pre-vaccination levels and the rate of return was more sensitive to the level of vaccine efficacy (0.10, 0.30, 0.50, and 0.70) for alternatives with greater vaccination effort (Fig. 6A). The level of vaccinated animals decreased toward zero as individuals were removed based on natural mortality rates (Fig. 6B).

5. Discussion

Vaccinated bison exposed to field strain *B. abortus* are less likely to become infectious and transmit the bacteria to other herd members. Model simulations suggest that syringe vaccination of females captured at the park boundary will provide only a small decrease in brucellosis infection due to low vaccination rates that rely on out-of-the-park migrations. Remote delivery vaccination extends the reach of management and allows for considerably more bison to be protected from infection. Thus, the greatest potential for reducing brucellosis infection could be achieved by combining vaccination at boundary capture pens with the remote delivery of vaccine throughout the park to all bison believed to be important in the maintenance of the disease. The projected reduction in seroprevalence results from disrupting the transmission cycle of *B. abortus* by reducing the quantity of *Brucella* bacteria shed onto the landscape and decreasing the exposure rate of susceptible bison. Thus, fewer animals are exposed and the number of seropositive bison removed during boundary capture operations decreases. Model simulations demonstrated that the interconnectedness of these variables was dependent on vaccine efficacy and vaccination effort. The sensitivity of vaccine efficacy was more pronounced in the alternatives involving remote vaccination due to the greater opportunities to vaccinate bison. However, improving the efficacy of a vaccine against *B. abortus* may take some time and increasing vaccination effort may compensate for less than desirable vaccine efficacy in the short term.

The current vaccine, SRB51, is not expected to provide lifetime protection and female bison may need booster vaccinations [20]. Thus, targeting only young animals for remote vaccination (Alternative 2) would increase the variability in seroprevalence declines because the level of vaccine protection would likely decrease as animals age. However, vaccine SRB51 is safe for multiple immunizations [35], which would reduce the uncertainty of protection in years following vaccination. Targeting all female bison (Alternative 3) allows animals to receive multiple vaccinations that extend the duration of vaccine protection and reduce the potential for latently infected bison to relapse into an infectious state.

The difficulty in monitoring the level of brucellosis infection within the population underscores the need for multiple indicators to evaluate the effectiveness of a vaccination program. Seroprevalence is an attractive indicator of infection because serum is easily obtained, diagnoses are quick and simple, and sampling does not involve killing the animal. However, seroprevalence indicates a history of exposure (i.e., antibody responses) and does not provide a complete picture of how bison may be responding to vaccination because rates of active infection are likely to be much lower than indicated by seroprevalence [33]. Thus, testing bison at boundary capture facilities should combine serologic tests with tissue culture on the seropositive bison that are shipped to slaughter. Because the antibody responses to *B. abortus* are long-lived, the proportion of actively infected bison would be expected to decrease faster in response to vaccination than population seroprevalence. Also, vaccinated bison that are subsequently exposed to field strain *Brucella* will react positively on serologic tests even though they may be protected from further transmission. These bison would be removed during boundary operations, thereby impeding the reduction of brucellosis infection. These bison play an important role in herd immunity by reducing the number of exposures of susceptible bison during an infectious event. Thus, a delay in seroprevalence decrease is expected in the first 10 years of initiating a vaccination program because of high population seroprevalence,

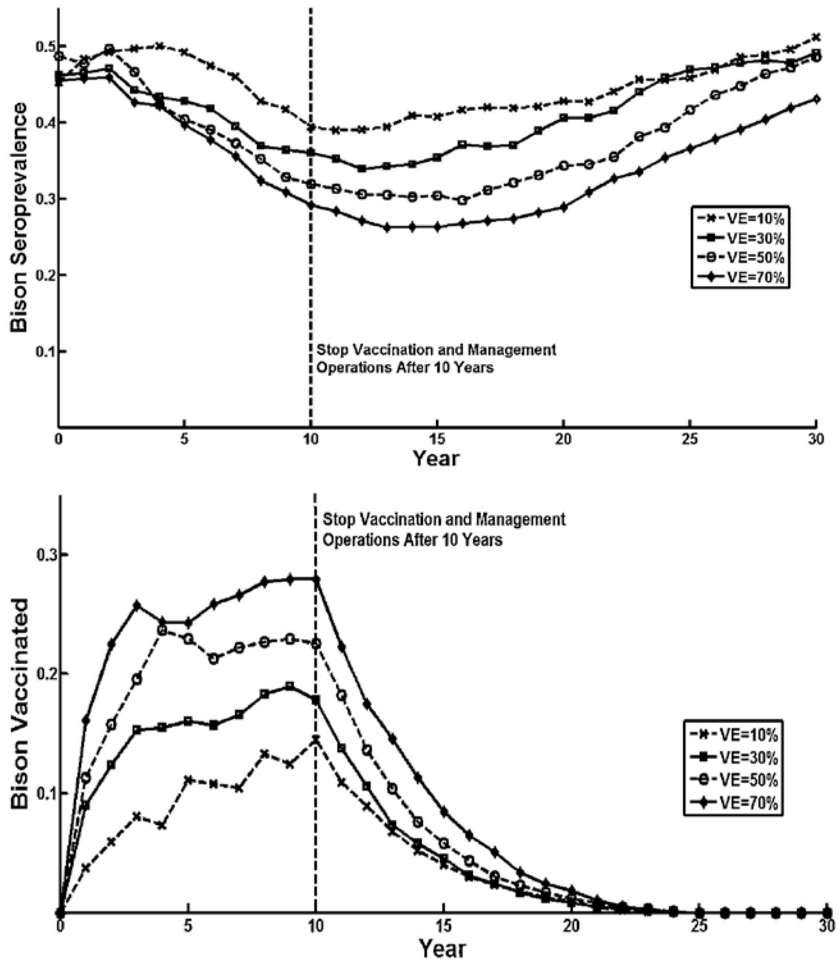

Fig. 6. Simulations of short-term (10 years) vaccination and boundary management for Alternative 3. Line markers correspond to the level of vaccine efficacy influencing seroprevalence declines (panel A) and the proportion of the bison population vaccinated (panel B).

long-lived antibodies, and the removal of vaccinated, seropositive bison.

Model simulations demonstrated an increase in seroprevalence as vaccinated bison were removed through natural mortality under short-tem vaccination scenarios. Even under high levels of vaccine efficacy, investment in short-term vaccination efforts will not reach long-term goals of reducing brucellosis infection in bison. Thus, a consistent long-term investment in vaccination will be required to meet the objective of the Interagency Bison Management Plan for reducing brucellosis transmission risk to cattle by reducing infection within Yellowstone bison. The precise level of acceptable risk has not been articulated, but model simulations indicate that brucellosis infection, as indexed by seroprevalence, can be substantially reduced with a vaccine of intermediate efficacy and realistic remote vaccination effort. Vaccination is likely to be a constant, long-term investment with the tools (i.e., vaccine, delivery method, and diagnostics) currently available. Reductions in the level of infection can be achieved, but will require a strong surveillance program to validate the corresponding decrease in infection with vaccination effort.

There is still much to be learned before remote delivery vaccination becomes operationally feasible. The efficacy of vaccine SRB51 has not been tested under field conditions and research is needed to estimate its efficacy within the Yellowstone system. Also, the duration of vaccine protection offered by SRB51 is unknown, but undoubtedly plays an important role in reducing infection and transmission. Yellowstone bison experience strong seasonal changes that cause stress and a reduction in nutritional condition. How bison respond to vaccination under these conditions will be important for estimating responses to exposure after vaccination. Also, the bio-bullet delivery method has been validated under experimental conditions, but its effectiveness has not been evaluated in Yellowstone bison. In addition, realistic group responses of bison to vaccination are largely unknown, and disturbances from remote vaccination may make bison difficult to vaccinate with this method over the long term. Remote vaccination effort will be unable to compensate for vaccine efficacy if bison are difficult to vaccinate.

The large proportion (0.5) of young, immature bison in Yellowstone that are seropositive indicates that exposure to *B. abortus* occurs early in life. However, little is known about transmission through infected milk or trans-placental transmission in bison. The risk of this route of exposure increases the need to vaccinate reproductively mature cows to reduce mammary gland and placental infection. A greater understanding of this potentially important route of transmission will lead to improved surveillance methods and parameterizing more detailed transmission models. Also, latent carriers of *B. abortus* are well documented, but the causes of recrudescence are speculative. Thus, all the potential transmission routes and female age classes contributing to transmission require further investigation.

Conflict of Interest Statement

All authors declare they have no conflict of interest

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Appendix H: Section 7 Consultation Concurrence Letter

United States Department of the Interior

FISH AND WILDLIFE SERVICE

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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)

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U.S. Department of the Interior

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