Risk of transmission from wildlife to cattle — The issue of the risk of transmission from bison to cattle is central to an evaluation of the benefits and costs of the proposed alternatives. The NAS (1998) report notes (p. 43) that

> One of the most contentious issues — because it is key to determining the need for control of the disease in Greater Yellowstone Area wildlife — is the probability of transmission of brucellosis between free-roaming bison and domestic livestock. Nearly all parties to the controversy agree that the risk of transmission of brucellosis from bison to cattle in the Greater Yellowstone Area is small, but not zero. Defining small depends on whether transmission has occurred in the past and, if so, how often. That is key to determining the need to control brucellosis in bison.

For purposes of the benefit-cost analysis regarding this issue, it is necessary to define the with- and without-plan risk of transmission. The reduction in risk is a benefit of the plan.

First, with regard to "with-plan" risk, it appears to be approximately zero. All of the alternatives rely on temporal and spatial separation of cattle and the definition of a boundary beyond which bison will not be tolerated. The judgement of the NAS (1998) report is that "There is no risk of *Brucella abortus* transmission to cattle from bison if bison do not leave Yellowstone National Park." Because bison are not permitted into areas with cattle or are removed from areas where cattle will graze following adequate temporal separation (approximately 45 days), the risk of transmission is near zero. All of the alternatives described here incorporate this spatial and temporal separation. For example, alternative 1 relies on strict border enforcement to keep bison and cattle separate. Sometimes in an environmental impact statement the "no-action" alternative provides for "no program." Benefits are measured for a given alternative by comparison to this "no-program " alternative. For this case the "no-action" alternative is the current interim plan which has been in place with some modification since 1996. Since the "no-action" alternative essentially reduces the risk of transmission to near zero, and all other alternatives do likewise, there are no measurable benefits with regard to reductions in the risk of transmission for any of the alternatives. This anomaly has been noted by some commenters who responded to the *Draft Environmental Impact Statement.*

To address the question of whether the proposed expenditures on protecting the Montana cattle industry from brucellosis are justified, it is necessary to identify some "without plan" situations that are possibly worth avoiding. The *Draft Environmental Impact Statement* identified factors that affect the risk of transmission (p. v):

degree of association between potentially infectious and susceptible animals

number and density of infectious animals

number of susceptible animals

environmental factors affecting viability of organism outside host

class of infectious animals (pregnant bison are higher risk)

vaccination and neutering

some animals are naturally resistant

It is noteworthy that the NAS report (1998) recognizes that "The risk of transmission is determined by the number of abortions that occur, the presence and survival of *Brucella abortus* in aborted tissues, and the exposure to a susceptible host."

For purposes of this analysis, the planning areas of interest for the "without-plan" setting are the SMAs north and west of Yellowstone National Park and the planning period is 2000 to 2015. Estimating the bison population that would be wintering outside the park in the absence of a plan is problematic. The closest estimate would be the results from the stochastic model under alternative 2, which shows bison populations growing to a total of 5,246 animals by 2014, with 1,643 animals wintering on lands north and west of the park. However, this scenario includes substantial bison removals. With no removals and using an 8.2% annual growth rate, the population would reach about 8,000 animals by 2015, with an average of 1,500 bison wintering outside the park during the planning period (bison population estimates from the new stochastic model results were used in this analysis). The NAS (1998) study suggests a constant incremental growth model might be appropriate, which would lead to lower populations. This projection also relies on the general findings from the NAS report that natural regulation does not appear to limit bison populations in Yellowstone National Park, at least at the historical levels observed. As the study notes (NAS 1998) "The lack of stabilization of bison population growth over time since the natural regulation policy was adopted suggests that bison have expanded like a wave front across suitable habitat in [Yellowstone National Park] with little diminution until now they are pressing against the borders of Yellowstone National Park in winter." An unanswered question is, "At what population level would some bison no longer return to the park in the summer?"

With regard to other "without-plan" factors, the seroprevalence in bison is 30%–40%, the cattle population is potentially as high as 2,224 pairs (698 on allotments), calfhood vaccination of cattle in the SMAs is 100%, and the bison abortion rate is unknown. The NAS (1998) report cites only two known bison abortions in the last decade, but the probability of observing an abortion is probably quite low. A complicating factor is the presence of seroprevalent elk, which can reinfect bison or directly infect cattle. For the planning area, elk potentially mixing with cattle during pregnancy and birthing numbers 2,000 to 6,000, seroprevalence is low (1%– 2%), and the Northern elk herd abortion rate is unknown. These parameters are summarized in table 58.

TABLE 58: FACTORS AFFECTING RISK OF BRUCELLOSIS TRANSMISSION FROM BISON TO CATTLE, BY AREA

Factor	Without-Plan Northwest of Yellowstone National Park 2000–2015	Historical Northwest of Yellowstone National Park 1917–1989	Historical Jackson, Wyoming, Region 1969–present	
Bison population in cattle range	0 to 4,500[1] Mean of 1,541	Few to 150[2] (1943–1967)	16 to 380[3] (1969 to present)	
Bison seroprevalence[3]	30%–40%	20%–73%	77%	
Bison abortion rate	Not known	-	4% to 6%[6]	
Cattle population on allotments			**Grand Teton National Park[4]**	**Bridger-Teton National Forest[4]**
Before 6/15	-	-	1,425	4,106
After 6/15	698[5]	-	2,100	7,885
Cattle on private	1,526[5]	-	-	-
Total cattle	2,224	-	9,985	
Elk population in cattle range	2,000–6,000	-	9,300[4]	
Elk seroprevalence	1%–2%[3]	-	37.5%[3]	
Elk abortion rate	-	-	7%–12.5%[3]	

1. Based on 1999–2000 population of 2470, 8.2% growth and bison wintering outside park are the excess of population over 3500.
2. Meagher 1973.
3. NAS 1998 — as a percent of pregnancies.
4. Smith and Robbins 1994.
5. Tables 22 through 25.
6. Howe 1997. This is a wholeherd rate apparently over a 4-year period, based on the estimated 9 to 15 aborted fetuses over the years 1992–96.

Given the description of the "without-plan" setting, there are several ways to estimate the risk of transmission. One approach would be to develop a formal risk assessment model. Another approach is to estimate an approximate bound to the risk by examining the epidemiological record for the area in question or a similar area.

Brucellosis was first found in Yellowstone National Park bison in 1917. The border was controlled beginning in 1968. For the period 1942 to 1967, there were 22 instances where bison were known to have moved beyond west and north park boundaries (Meagher 1973). A number of bison were also outside the park in 1988 and 1989. It has not been possible to determine whether or not brucellosis transmission from wildlife to cattle has occurred from 1917 to present in this area, although no documented cases of such transmission are known. Several of the risk factors for the planning area in the historical period since 1917 and prior to formal control plans are also summarized in table 58. While many of the variables may be at the same or nearly the same level as for the planning period, bison populations in the past were much lower and occasions when bison were outside the park were limited compared with what is projected for the "without-plan" case. Given the much higher bison populations projected for future years, the historical epidemiological record for the planning area does not provide an upper bound to the future risk of transmission. In any case, the observed risk is zero.

A second possible source is to examine the epidemiological record for the Jackson, Wyoming, area — specifically Grand Teton National Park and the Gros Ventre drainage area of the Bridger-Teton National Forest to the west of the park. The Jackson bison herd became freeranging in 1969 and is thought to have acquired brucellosis from feeding with elk on the National Elk Refuge (in the mid-1970s. This herd has numbered from 16 to 380 (its current population level). The seroprevalence is estimated to be 77% and one study (Howe 1997) used an abortion rate of 4% to 6% (apparently as the number of estimated aborted fetuses over a four year period as a percent of the total herd size) for modelling purposes. The number of cattle on allotments in the area prior to June 15 include 1,425 in Grand Teton National Park and 4,106 on the adjacent Gros Ventre drainage area of the Bridger-Teton National Forest. Total cattle on the summer range are 9,985 pairs (Smith and Robbins 1994). The elk population wintering on the National Elk Refuge and Gros Ventre feeding grounds averages 9,300. The seroprevalence in these elk is 37% and the elk abortion rate is estimated to be 7%–12.5%.

In comparing the "without-plan" case and the historical Jackson area case, it appears that accounting for both population and seroprevalence and other things equal, the risk associated with the Yellowstone National Park bison population alone is about five times higher in the "without-plan." (This ratio is calculated from the data in table 58 using a mean of 1,541 bison for the "without plan" and an average seroprevalence of 35% in Yellowstone bison; and a mean of 150 bison and a seroprevalence rate of 77% for bison in the Jackson area.) However, this difference may be more than offset by the much greater association of cattle with wildlife in the Jackson area and the approximately five times higher cattle population at risk. North and west of Yellowstone National Park, bison are generally off the winter range and back in the park well before the first cattle come onto the allotments — and none of these are before June 15. (Of course, this could change if bison populations continued to grow unabated.) In contrast, most of the Grand Teton National Park cattle are on pasture by mid-May and about half the cattle on the Bridger-Teton National Forest are moved in before June 15. The NAS (1998) report notes "Bison are in contact with cattle as they cross private lands during migration and cattle trail driveways in spring and fall and on grazing allotments on Grand Teton National Park and U.S. Forest Service lands in summer (Smith and Robbins 1994). Another factor is the percentage of cattle that are calfhood vaccinated against brucellosis. This is known to be 100% at present in the planning area. The vaccination rate in the Jackson area during the historical period is not known, but at least one ranch in the near vicinity (the Parker Ranch at Dubois) is known to have had vaccination rates of only 20% to 40% for several herd samples in 1989 (based on court records for Parker v. United States).

In interpreting the epidemiological record for the Jackson area, it is noteworthy that the risk factor associated with elk in the Jackson area appears to be much greater than for elk in the planning area. There are large numbers of elk, the seroprevalence is relatively high, and the elk share late spring and summer range with large numbers of cattle. As the NAS (1998)reports "..the sheer numbers of elk, their proximity to grazing allotments, cattle trailing areas, and private ranches, and their relatively higher seropositive rates means that the relative risk of transmission of *Brucella abortus* from elk to cattle is greater than for the northern herd elk." However, in comparison to bison, elk are less gregarious and are less likely to associate with cattle.

As noted, the risk of transmission is largely a function of the number of abortions and exposure to a susceptible host. There is, unfortunately, considerable uncertainty about both seroprevalence rates and abortion rates. Nonetheless, it is instructive to roughly compare the approximate number of abortions for both bison and elk from the number of abortions published estimates listed in table 58. Although abortion rates for Yellowstone area elk and bison are unknown, they can be estimated based on rates for Grand Teton animals and adjusted for relative seroprevalence. Using these adjusted estimates of abortion rates, seroprevalence and populations, it is likely that the average number of combined bison and elk abortions through the planning period in the Jackson area herds would be about five to ten times higher than for Yellowstone area elk and bison. This is primarily due to the large number of serprevalent elk in and around the National Elk Refuge. Considering the much higher numbers of cattle in the Jackson area and the greater degree of association, the epidemiological record for brucellosis transmissions from wildlife to cattle for the Jackson area might provide an upper bound for an estimate for the planning area in the "without-plan" case. A key uncertainty is how the distribution and seasonal movements of the Yellowstone National Park bison herd would change as the population doubles from the previous maximum levels of nearly 4,000 bison.

The next section summarizes the epidemiological evidence on wildlife to cattle transmissions in Wyoming. This data is used to approximate an upper bound for the annual risk of transmission from bison to cattle north and west of Yellowstone National Park in the planning period. Following this, a statistical model is presented to estimate (given the probability of an occurrence in any given year) the probability of two occurrences in any given year or an occurrence in each of two consecutive years over the next 15 years (the planning horizon for this environmental impact statement). The occurrence of two brucellosis outbreaks within two years corresponds to the APHIS standard for changing a state or sub-state area from class-free to class A status, as noted in the preceding section.

Jackson area epidemiological record

The NAS (1998) report summarizes the controversy over the epidemiological record in the Greater Yellowstone Area:

> Advocates of no control maintain adamantly that no case of transmission of brucellosis from bison to cattle in the free-roaming state in the Greater Yellowstone Area has ever been documented. Advocates of the need to control the disease in bison to protect livestock in the surrounding areas maintain equally stoutly that there is clear epidemiologic evidence that transmission from wildlife has occurred at least six times in the recent past, two of which might have been due to bison.

The report then goes on to note that the epidemiological evidence is

> summarized in a field report submitted to APHIS in December 1966. Between 1961 and 1989, cattle on six ranches in the Greater Yellowstone

> Area became seropositive for brucellosis after testing brucellosis-free...In four of the cases, anecdotal evidence was provided that elk were adjacent to or moving onto the property; the other two cases included anecdotal evidence of elk and bison presence...Those six cases of purported transmission of brucellosis from wildlife to cattle are based on circumstantial evidence.

After considering the lack of documentation and record retention and noting the possibility that the disease might not have been entirely eliminated in cattle initially, the NAS (1998) report concludes that "Given the ambiguity allowed by epidemiological evidence in this situation, wildlife cannot be determined to be the source of brucellosis infection in these six cases."

The NAS (1998) report also notes that one of these outbreaks led to court cases (Parker vs. United States 1992; Peck vs. United States 1992). The Wyoming Supreme Court upheld the factual findings of the Wyoming Game and Fish Commission that Parker (a rancher) had failed to establish a causal connection between the presence of brucellosis in his cattle herd and the alleged presence of brucellosis in nearby elk or bison. Several of the justices assessed the evidence themselves and concluded that the probability of disease transmission from elk or bison to one or more of Parker's cattle was remote.

To conclude, the finding of both the NAS (1998) report (with regard to all six alleged wildlife transmissions) and the court case (with regard to just the Parker case) is that there is no solid evidence of a wildlife transmission to cattle in the Jackson area. A review of the APHIS report concerning these six cases show them all to be in Wyoming. Four of the cases were on ranches located a good distance (40 to 60 miles southwest and southeast) from Jackson near the towns of Alpine Junction, Wyoming (in 1961 and again in 1969 at the same ranch), Bondurant, Wyoming (in 1982), Cora, Wyoming (in 1983), and Etna, Wyoming (in 1985). In all of these cases, the alleged transmission was from elk, and in two of the cases, the ranches were in close proximity to state elk feeding grounds (Alpine Elk Feedground and Black Butte Elk Feedground). In any event, these four cases are well removed from the range of the Jackson elk herd and the Jackson bison herd. Of the two remaining cases, the only one in Teton County was at a ranch 6.5 miles north of Jackson — apparently in the Gros Ventre Junction area near the border of the National Elk Refuge and Grand Teton National Park. This transmission is alleged to have been from bison or elk, which certainly seems plausible given the location. However, Smith and Robbins (1994, p. 40) "Doubt remains whether this was an actual field-strain brucellosis infection or a vaccination phenomenon (e.g., inadvertent revaccination or infection with vaccine strain

Brucella abortus. Attempts to culture organisms from tissues of reactors were unsuccessful..." The only other case allegedly involving wildlife that could conceivably be from the Jackson herds was the previously mentioned Parker case (1989). However, this ranch is located on the other side of the continental divide about 60 miles east of Jackson and Moran Junction. The evidence in this case linking wildlife to the transmission is anecdote, e.g., "There was a bull bison sighting in one of Parker's allotments and several bison sightings on an adjacent allotment during late July and early August of 1988. It is unknown whether there was any commingling with cattle" (GYIBC 1997). As noted in the related court case, it was concluded that transmission from wildlife was not established.

To summarize, the NAS (1998) concludes there are no well-documented cases of wildlife transmission to cattle in the Greater Yellowstone Area. A more generous interpretation is that there might be, at most, two cases that could conceivably be traced to the Jackson bison and elk herds during the historic period.

Estimated risk of brucellosis transmission and loss of class-free status

Given the uncertainty of the epidemiological record, a range of probabilities were examined to approximate the annual risk of brucellosis transmission from bison to cattle north and west of Yellowstone National Park. The data can be interpreted in more than one way. The number of cases in Teton County from 1951 to the present is, at most, one Smith and Robbins (1994). This would imply about a 1 in 50 chance or an annual probability of 0.02. Given the uncertainty in the data, sensitivity of estimates to an even lower probability, such as 1 in 100 or 0.010, might be of interest. Another interpretation would be to consider only the record since Grand Teton National Park bison were free ranging (beginning in 1969) This would imply a 1 in 31 chance or a 0.032 annual probability. The most generous possible interpretation is that there have been two cases in the last 31 years or a 0.065 annual probability.

If the annual probability of an occurrence is known, the associated probability of a loss of class-free status for the Montana livestock industry can be computed. As noted, under APHIS regulations, two occurrences within a two years period if certain conditions are met. Per APHIS regulations, if only one affected herd is disclosed, but that herd cannot be depopulated within 60 days, (the owner will not allow it due to genetics, or if the herd is too large and funding is not available) or the associated required epidemiologic investigation and/or testing is not completed within 60 days, the state may still lose its class-free status. What is required then is to compute the probability of incidents in at least two consecutive years out of the next 15 years of the planning period. This problem can be approached using a Bernoulli model and a Poisson model.

It should be noted that it is also possible for a loss of class-free status to occur if there is an incident of brucellosis occurrence and the associated investigation discloses that the infection has spread to an associated herd. The APHIS report (summarized in GYIBC 1997) indicates that no reactors caused by contact with the infected herd were found in any of the associated or contact herds in any of the six cases. Although the probability of infection spreading is clearly not zero, this data suggests the probability is quite small and has not been modelled here. It is noteworthy that the investigations did disclose one reactor in the 1982 case near Bondurant, Wyoming. However, the infected cow was a 1981 import from another state that was kept at the home place and did not associate with the infected herd.

Bernoulli Model — Let *n* be the total number of years in the analysis and *p* be the probability of an incident in a given year. The Bernoulli model assumes that years are independent and that the probability of an incident is constant from year to year. Let *X* be the number of years with an incident in the n years. Then *X* has a binomial distribution with parameters *n* and *p*. Therefore,

$$\Pr(X=x) = \binom{n}{x} p^{x}(1-p)^{n-x}$$

Table 59 gives the values of these probabilities for n=15 and various values of x and p. The probability of at least one incident in 15 years is then one minus the probability of no incidents (x=0).

TABLE 59: PROBABILITY OF INCIDENTS IN *X* YEARS OUT OF 15 WITH PROBABILITY *P* OF AN INCIDENT IN ANY ONE YEAR (BERNOULLI MODEL)

p	*x*				
	0	1	2	3	≥4
.010	.8601	.1303	.0092	.00040	.00001
.020	.7386	.2261	.0323	.00286	.00018
.025	.6840	.2631	.0472	.00525	.00043
.032	.6139	.3044	.0704	.01009	.00108
.065	.3649	.3805	.1852	.05578	.01364

The probability of incidents in at least two consecutive years out of n years is more complicated to compute. It is easier to look at the probability of the complement of this event, i.e., the probability of no run of at least two years with incidents over n years. Let A_i be the event that there is no run of at least two years with incidents over a period of i years. Then $\Pr(A_i)$ can be calculated recursively:

$$\Pr(A_i) = (1-p)\Pr(A_{i-1})+p(1-p)\Pr(A_{i-2})$$

The probability of no run of two incidents in i years can be broken down into two cases: either there isn't an incident in the i^{th} year or there is an incident. If there isn't an incident in the i^{th} year (probability $1-p$), then the probability of no run of two incidents for all i years is the probability of no run of two in the first i-1 years. This is represented by the first term on the right-hand side of the equation. If there is an incident in the i^{th} year (probability p), then the probability of no run of two incidents is the probability of no incident in the (i-1)th year times the probability of no run of two in the first i-2 years. This is the second term on the right-hand side of the equation. Need to note that

$$\Pr(A_0) = \Pr(A_1)=1$$

Table 60 gives the probability of incidents in at least two consecutive years out of 15, i.e., $1-\Pr(A_{15})$, for various values of p.

TABLE 60: PROBABILITY OF INCIDENTS IN AT LEAST TWO CONSECUTIVE YEARS OUT OF 15 YEARS WITH PROBABILITY *P* OF AN INCIDENT IN ANY ONE YEAR (BERNOULLI MODEL)

p	Probability of Incidents in Two Consecutive Years out of 15
.010	.00139
.020	.00549
.025	.00852
.032	.01384
.065	.05455

Poisson model — The Bernoulli model does not take into account the possibility of two or more incidents in one year. Since the empirical data does not allow the direct estimation of two or more incidents in one year, it is necessary to build a model. A reasonable starting model would be the Poisson model, which assumes incidents happen randomly over time. The parameter of the Poisson is the mean number of incidents per unit of time (one year, in this case). If X is the number of incidents in one year, then the probability of x incidents in one year is given by

$$\Pr(X=x) = \left(\frac{e^{-\lambda}\lambda^{x}}{x!}\right), \text{ where } x=0, 1, 2\ldots$$

The probability of either two or more incidents in one year or one incident in each of two consecutive years is of primary interest. To calculate this probability, this set of outcomes is divided into two disjoint subsets: B_1 — two or more incidents in at least one year out of n, and B_2 — no more than one incident in any one year but incidents in at least one run of two consecutive years. Then

$$\begin{aligned}\Pr(B_1) &= 1\text{-}\Pr(0 \text{ or } 1 \text{ incident in each of } n \text{ years})\\ &= 1\text{-}[\Pr(X=0)+\Pr(X=1)]^{n}\\ &= 1\text{-}[e^{-\lambda}+\lambda e^{-\lambda}]^{n}\\ &= 1\text{-}[(1+\lambda)e^{-\lambda}]^{n}\end{aligned}$$

The probability of B_2 is the probability of no more than one incident in any one year times the conditional probability of incidents in at least one run of two years, given no more than one incident in any of the years, i.e.,

$$\begin{aligned}\Pr(B_2) = {} & 1\text{-}\Pr(0 \text{ or } 1 \text{ incident in every year}) \times\\ & \Pr(\text{incidents in at least 2 consecutive years} \mid 0 \text{ or}\\ & 1 \text{ incident in every year})\end{aligned}$$

The first of these probabilities is simply 1-Pr(B_1); the second is computed just as 1-Pr(A_i) was computed in the previous section, except that the probability of an incident in any one year is now the conditional probability of one incident given there were 0 or 1 incidents:

$$\begin{aligned}p &= \Pr(X=1 \mid X=0 \text{ or } X=1)\\ &= \frac{\Pr(X=1)}{\Pr(X=0 \text{ or } X=1)}\\ &= \frac{\lambda e^{-\lambda}}{e^{-\lambda}+\lambda e^{-\lambda}} = \frac{\lambda}{1+\lambda}\end{aligned}$$

The probability of either two or more incidents in one year or incidents in two consecutive years is Pr(B_1) + Pr(B_2) since B_1 and B_2 are disjoint. This probability is calculated for several values of λ in table 61, where λ represents the mean number of incidents per year. This would normally be estimated from sample data by the total number of incidents observed over some number of years divided by the number of years.

Table 61: Probability of Two or More Incidents Either in One Year or Over Two Consecutive Years

λ	r(B_1)	Pr(B_2)	Probability of Either Two Incidents in One Year or Incidents in Two or More Consecutive Years = Pr(B_1)+Pr(B_2)
.010	.00074	.00136	.00210
.020	.00296	.00526	.00822
.025	.00460	.00808	.01268
.032	.00749	.01292	.02041
.065	.02992	.04694	.07686

Violation of the model assumptions — The models in previous sections assume that the probability of an incident is constant from year to year. This assumption would not be valid if incidents are more likely to occur under certain environmental conditions than others. It is likely that the probabilities computed for the Bernoulli model would not be overly affected if the yearly probability of an incident varied randomly by a relatively small amount over time and that probabilities from year to year were independent. However, if the yearly probabilities were positively correlated over time, then the probability of incidents in two consecutive years would be higher than those calculated for the Bernoulli model. The same is true for the Poisson model if λ (the mean number of incidents per year) varied from year to year. The probability of two or more incidents in one year would also be increased in the Poisson model if λ varied, even if the λs were not serially correlated.

Although the Bernoulli and Poisson models could be modified to incorporate varying p or λ, there is not enough information available to quantify how much these parameters should vary and whether there is serial correlation and how much variation exists. Even experts in the field would have difficulty quantifying these parameters since knowledge is limited and little information exists in the literature.

The general finding of these models is that the Poisson model generally provides a more conservative result (higher risk of loss of class-free status, given any specific annual probability). Table 62 provides a summary of the plausible range of annual probabilities and the associated estimates of the probability of a loss of class-free status. This table also shows the probability weighted expected costs of a loss of class-free status in Montana over the next 15 years. This is computed using the economic costs associated with the loss of class-free status outlined in a previous section. For example, if the class-free status changes to a class A area for the entire state of Montana, additional testing costs per year are estimated to be $5.1 million to $16.3 million with a mean of $10.7 million. The loss of class-free status is assumed to last for three years. Since the loss could occur beginning in any of the next 15 years, an average present value factor (0.607) is used for each of the 15 years. Including depopulation costs of two herds (see notes to table 62), the total present value is $19.63 million. If the probability of a loss of class-free status is 0.00210 (corresponding to an annual probability of occurrence of 0.01, then the expected cost is $41,223. However, if the annual probability is 2 in 31 years or 0.065, the expected cost over the life of the plan has a present value of $1.5 million. This would correspond to an annual expected cost of $166,000 each year over the life of the plan.

This latter value provides an approximate upper bound for the expected costs of losing class-free status in the "without-plan" case and accordingly, is also a measure of the upper bound, for the benefits associated with controlling the risk of transmitting brucellosis from bison to cattle in any of the alternatives. This is an upper bound based on the interpretation of the epidemiological record for the Jackson area where, at most, no more than two cases of transmission of brucellosis actually occurred in this area from 1969 to present.

Table 62 also shows the range of costs for alternative institutional responses to the loss of class-free status. As noted, APHIS regulations allow a state to choose a two-area classification; a class A area smaller than the entire state can be established if necessary. By establishing a class A area equal to just Park and Gallatin Counties or even just the SMAs, Montana could greatly reduce the expected cost and risk to its cattle industry associated with a possible loss of class-free status. The enforcement costs and most plausible boundaries for such an area are beyond the scope of this investigation. However, given that the potential areas are in a corner of the state and bounded on several sides by Yellowstone National Park and by the Idaho state line on another side, the costs of monitoring and enforcement could be comparatively low. For example, there are only three roads leading out of the SMAs and into

Montana (U.S. Highway 89 passing through Yankee Jim Canyon north of Gardiner, U.S. Highway 287 west into the Madison Valley, and U.S. Highway 191 north through the Gallatin Valley).

The probabilities in table 62 can also be used to compute the regional economic impacts to the state of Montana that could arise from a statewide or smaller area loss of class-free status. For example, for the statewide case, the effect of a price reduction could be a loss of $4.7 million to $22.5 million to Montana producers per year. Note that from a national benefit-cost standpoint, this price reduction is a cost to producers but has an equivalent benefit to buyers and so has a zero net impact on benefit-cost. From the standpoint of regional economics, however, the loss is only partially offset by compensation for herd reductions.

Table 62: Expected Costs of Loss of Montana, Two-County, or SMA Class-Free Status as a Function of Observed Annual Probability of Brucellosis Infection in Cattle

Odds of Infection[1]	Annual Probability of Infection	Probability of Loss of Class-Free Status[2]	Expected Costs of Loss of Class-Free Status		
			State[3]	Two County[4]	SMA[5]
1/100	.010	.00210	41,223	1,678	372
1/50	.020	.00822	161,359	6,566	1,457
1/31	.032	.02041	400,648	16,304	3,617
2/31	.065	.07686	1,508,762	61,398	13,622

1. For example, observed infection of cattle in 100 years.
2. Based on Poisson model of probability of 2 or more incidents in any 1 year or 2 or more consecutive years out of 15 years.
3. Present value for state of Montana loss of class-free status in mean annual testing costs of $10.7 million for 3 years, present value factor for average of any year in 15 is .607, herd size at 172 head and per head value of $750, depopulation per herd is $129,115 for 2 herds, total present value is $19.63 million.
4. Present value for Park and Gallatin County testing costs annual means of $352,600, other parameters same as the state, present value of $798,830 plus unknown costs of maintaining and defining the boundary.
5. Present values for SMAs north and west of Yellowstone National Park and average testing costs of $4,250, other parameters same as state, total present value of $177,231 plus unknown costs of maintaining and defining the boundary.

Given the considerable uncertainties involved in estimating the risk of transmission, table 63 is provided to offer decision makers another way of viewing the problem. The costs of the alternatives are known with greater certainty than the benefits of controlling the risk of an outbreak. Given the costs of achieving the objective of protecting Montana's livestock industry from brucellosis for any given alternative, one can compute the associated break-even probability of an occurrence. The latter is the probability level that would make the benefits of risk reduction (the expected costs of avoiding a loss of class-free status) just equal to the cost of implementing an alternative. For example, if an alternative would cost $216,000 per year over the life of the plan to reduce brucellosis infection risk to near zero, the probability of an occurrence necessary to justify this level of expenditure is one in 13.3 year (or 0.0753). (Recall that the highest probability associated with the Jackson area epidemiological record is 2 in 31 years or 0.0645.) This assumes that the state of Montana does not choose to economize on the cost of a loss of class-free status and the entire state is reclassified. If the state chose to split out a separate class A area, it would need to be known with certainty (probability 1.00) that not only would class-free status be lost in the next 15 years, but also that it would occur more than once.

Table 63: Breakeven Present Value and Annual Costs to Control Brucellosis Risk Given Probability of Occurrence

Frequency of One Occurrence Per Year	If Probability of an Event is:	Probability of Loss of Class-Free Status[1]	Breakeven Expected Costs[2] (millions $)	Breakeven Annual Costs (millions $)
1/13.3	.0753	.1000	1.963	0.216
1/8.8	.1131	.1999	3.924	0.431
1/6.8	.1468	.2999	5.887	0.646
1/5.6	.1801	.4001	7.854	0.862
1/4.7	.2148	.4999	9.813	1.077
1/3.9	.2532	.5999	11.776	1.293
1/3.4	.2983	.7000	13.741	1.509
1/2.8	.3564	.8000	15.704	1.724
1/2.2	.4464	.9000	17.667	1.940

1. Poisson model of 2 or more incidents in any 1 year or incidence in 2 or more consecutive years out of 15 years.
2. Assume state loss of level class A status for three years, cost of testing and herd depopulation present value is $19.63 million.

As another example, if the annual costs of reducing the risk of brucellosis were around $1.5 million, and assuming the entire state goes to class A status, a brucellosis outbreak would be expected every 3.4 years.

Benefits of Public Safety and Avoided Private Property Damages. Based on the discussion in "Affected Environment," the benefits associated with protecting public safety and preventing private property damage are relatively small and have not been quantified.

Commit to Eliminating Brucellosis in Wildlife. The NAS (1998) report characterizes this objective as "Total eradication of brucellosis as a goal is more a statement of principle than a workable program at present: neither sufficient information nor technical capability is available to implement a brucellosis-eradication program in the Greater Yellowstone Area." As a statement of principle, it is difficult to identify any direct benefits for this objective. Possible nonmarket benefits are discussed below.

Viable Population of Wild Bison. The "without plan" would result in a larger bison population than any of the listed alternatives. Accordingly, the "benefits" associated with this objective for the various alternatives are, if anything, negative. More pragmatically, the direct benefits of changes in the bison population are related to the direct use visitors make of these animals on their visits to Yellowstone National Park. This use is limited to observation and photography. While these direct-use values are in aggregate probably very large, the marginal values associated with the range of populations proposed could be quite small. In any case, the only available empirical estimates (discussed in "Affected Environment") are not significantly different from zero.

Research. While there is considerable ongoing research related to the bison-brucellosis issue (see appendix D), almost all of this work is ongoing outside the context of this environmental impact statement. The only action item related to this objective is a relatively low-cost item, wildlife/winter-use monitoring. The separate benefits of this objective would be difficult to estimate and to date, have not been estimated.

Cost-Effectiveness of the Alternative Actions and Objectives

A number of comments on the *Draft Environmental Impact Statement* suggested a need to provide a cost-effectiveness evaluation of the various alternatives. This type of analysis requires an evaluation of the costs and benefits of the specific proposed actions.

Table 64 provides a list of the many different specific proposed actions organized by the objectives they are intended to fulfill. This list draws on all of the alternatives and is intended to represent the full set of more-or-less generic possible actions that the different alternatives draw upon.

Protecting Livestock from Risk of Brucellosis. Most of the actions fall under the objective of protecting livestock and the livestock industry from brucellosis. An approximate upper bound to the direct benefits of achieving this objective was previously discussed and is estimated at $1.5 million (present value) or an annual value through the life of the plan of about $163,000 per year. This value is predicated on a loss of class-free status for the state of Montana. If a loss of class-free status could be restricted to a smaller area, such as Park and Gallatin Counties or the SMAs proposed in this plan, the costs are much lower. Implicitly, the development of a contingency plan for defining a smaller potential class A area is one specific cost-effective action that has not been included in the plan.

With respect to the general objective, the NAS (1998) report emphasizes that the separation of cattle and bison is a plausible first step to lowering the risk of brucellosis infection. This step is related to the objectives of defining and controlling a border beyond which bison are not tolerated and controlling bison populations. The major actions proposed for achieving these objectives are monitoring bison; agency shooting; bison hunting; capture, test, and slaughter operations; and quarantine. Monitoring bison is low cost ($44,000 annual) and is a necessary part of any of the other actions. Bison hunting has action-specific benefits (license fee revenues and nonmarket benefits to hunters) that potentially offset the direct costs — making this a low cost and cost-effective possible action. Hunters alone could not be relied on to maintain a border, which creates more of a population control action. There is additional uncertainty associated with this action in that it requires approval by the Montana legislature and eventually, acceptance by the public.

Table 64: Benefit-Cost of Bison Management Objectives and Actions — Summary of Range of Alternatives

Objective/Action[7]	Direct Benefits and Costs: Annual Costs[9]	Direct Benefits and Costs: Present-Value Costs	Direct Benefits and Costs: Present-Value Benefits	Present Value of Nonmarket Costs or Benefits	Net
(A) Protect Livestock from Risk of Brucellosis[1]					
1. Monitoring of bison	44,000[10]	400,700	≤1,514,000[2]	-	-
2. Agency shooting	[11]	-	≤1,514,000[2]	-	-
3. Calfhood vaccination of cattle with RB51	-	[13]	≤1,514,000[2]	-	-
4. Surveillance testing of cattle	-	-	-	-	-
5. Other cattle management actions[3]	-	-	-	-	-
6. Modify national forest grazing allotments	-	88,000[18]	-	-	-
7. Bison hunting	66,000[16] 389,200	481,000 175,100	185,700–	58,400–	-
8a. Capture, test, and slaughter operations at boundaries	264,000– 963,500	2,471,294– 8,829,400[12]	128,500– 475,400[19]	-	-
9. Vaccination of bison	330,500– 338,000	2,145,000– 2,321,100	-	-	-
10. Quarantine bison 4,372,600[15]	447,500[14] 1,796,300	4,282,100–	825,800–	-	-
11. Winter road grooming	55,000– 575,960[21]	401,500– 1,511,500	[22]	-	-
(B) Public Safety, Private Property Damage					
12. Remove bison at landowner request[4]	-	-	-	-	-
(C) Commit to Eliminating Brucellosis in Wildlife					
8b. Herd-wide capture, test, and slaughter operations — alternative 5[5]	2,636,760	11,292,000	376,400	1,695,150[5]	-

Table 64: Benefit-Cost of Bison Management Objectives and Actions — Summary of Range of Alternatives *(continued)*

Objective/Action[7]	Direct Benefits and Costs			Present Value of Nonmarket Costs or Benefits	Net
	Annual Costs[9]	Present-Value Costs	Present-Value Benefits		
8c. Herd-wide capture, test, and slaughter — alternative 6[23]	2,132,560–2,678,160	9,931,357	411,600	-	-
(D) Viable Population of Wild Bison[6]					
13. Bison population range[8]	-	0[17]	-	-	-
14. Bison management on public lands	-	-	-	-	-
15. Acquire additional wildlife habitat	-	15,100,000[17]	-	4,177,700–4,177,727	-
(E) Research					
16. Wildlife/winter-use monitoring	5,500–27,500[20]	50,100–200,747	-	-	-
TOTALS	-	5,705,241–15,822,800	1,642,500–3,785,700	81,700–4,203,100	(8,768,700) -81,959

1. Includes objectives 1,2,5, and 6 in table 11.
2. Benefit to satisfaction of all four objectives is the expected present value of loss of class-free status for the entire state, if based on a risk of brucellosis infection, is 2 in 31 years. For Gallatin and Park Counties, the corresponding estimate is $61,398. For the SMAs it is $13,622.
3. Other cattle management actions are listed under the same objective/alternative in table 11, but are not line items in table 12 or line items in alternative-specific cost tables, including: 1) test/vaccinate adult cattle and 2) conversion to steer/spayed heifer operations.
4. Bison hunting could also contribute to this objective, but is not sufficient to accomplish it.
5. Vaccination of bison may also contribute to this objective, but is not sufficient to accomplish it.
6. Also includes elements of objective 1.
7. List of actions based on table 11, except for addition of "other cattle management actions." Contingency plans not listed as a separate action may modify timing or extent of many actions listed here.
8. This is more of an outcome than an action.
9. Costs are derived from alternative specific cost tables to the extent possible. Costs are often not broken out at the action/objective level.

Table 64: Benefit-Cost of Bison Management Objectives and Actions — Summary of Range of Alternatives *(continued)*

10. Based on alternative 2.
11. Based on alternative 2.
12. Alternatives 7 and the modified preferred alternative etc. assume capture facility costs are sunk costs (total of $379,000, modified preferred alternative). Includes equipment repair and replacement.
13. No specific costs were broken out in the "Alternatives" cost tables for this action.
14. Based on the modified preferred alternative.
15. Includes average of range of costs $550,000 to $880,000, (alternatives 7 and 8) for quarantine facility.
16. Alternative 7.
17. $29.1 million to acquire level 1 (exp. alternatives 7 and 8) are sunk costs (lands already acquired). Cost for level 2 is based on alternative 2 less $29.1 million.
18. Based on alternative 2.
19. Revenue from sale of hides, horns, and meat is based on average $337 value per animal.
20. Alternative 2.
21. Snowmobile enforcement, alternative 2.
22. Savings from not plowing roads in alternative 2.
23. Alternative 6.

The actions remaining that would actually control bison population are the alternative actions, including agency shooting, capture, test, and slaughter operations, and quarantine. Only agency shooting is justified within the range of estimated direct benefits — costs of about $200,000 per year are somewhat more than estimated benefits. Capture, test, and slaughter operations include facility costs and costs vary across alternatives from $2.5 million to $8.8 million (present value). This is only partially offset by revenues from the sale of slaughtered animals. There is an additional unquantified benefit of reducing seroprevalence in bison, but this benefit is likely to be small, given the remaining risk to be controlled once spatial and temporal separation is ensured. Another perspective on the benefit of reducing seroprevalence, e.g., by about one-half, is that this has about the same effect on risk as reducing the number of cattle at risk by one-half. Accordingly, there are more cost-effective ways of achieving similar reductions in risk, such as modification of national forest grazing allotments. The value of the past grazing resources is relatively low (around $2 to $12 per animal unit month) and the one-time administrative costs are also low.

Quarantine costs are around $4.3 million, but costs can be offset by $0.8 to $1.8 million when live bison are either sold or distributed. These live bison will leave the park and could be used for commercial or tribal livestock operations. Accordingly, their value is based on the auction value for live bison. Quarantine cannot be justified based on the cost relative to the total benefits for this objective. It is also not a cost-effective way to produce disease-free bison for commercial herds, since each bison will cost two to four times as much as it will return. These costs are high because of facility and operating costs and the amount of time bison will have to be in quarantine.

The lowest cost actions listed in the table are for the management of cattle. These include calfhood vaccination, surveillance testing, testing/vaccination of adult contact cattle, and conversion to steer/spayed heifer operations. All of these actions are likely to be cost-effective. Some of these are already being undertaken but exact costs (conversion to steer/spayed-heifer operations) have not been computed. The latter costs are likely to be low since the potential number of livestock involved is small and the costs are bounded by the net economic returns to these herds.

With respect to winter road grooming, the costs are within the range of the direct benefits for this objective. However, the NAS (1998) report suggests that in the long-term, the contribution of this action to the objectives at issue may be low or negligible. The report (NAS 1998) notes that bison movement seems to be mostly correlated to bison populations and secondly to snow depths and concludes "The suggestion that discontinuing winter road grooming will contain bison better within [Yellowstone National Park] and that starvation and other natural factors will relieve the need for artificial control outside the park appears optimistic." To date, the research to test this hypothesis by closing roads has not been undertaken. Given a possibly low probability of contributing to the objective, the known costs of road grooming likely outweigh the expected possible benefits.

Public Safety and Private Property Damage. The only specific action mentioned to satisfy this objective is removal of bison at landowners request. The costs for this action have not been separately calculated but the costs are likely to be low, as are the benefits of the avoided costs of damage.

Commit to Eliminating Brucellosis in Wildlife. The NAS (1998) study suggests that this objective can be interpreted as a statement of principle. The direct benefits of committing to a statement of principle would be difficult to quantify. Vaccination could be listed as an action under this objective as evidence of a commitment. However, vaccination is included in the first set of objectives related to protecting livestock from brucellosis. Accordingly, vaccination as an action is examined under the first set of objectives relating to protecting livestock from brucellosis.

Herd-wide capture, test, and slaughter operations is a specific action that could be used to aggressively lower seroprevalence, as it has been in alternatives 5 and 6. The difference is that in alternative 6, the herd-wide capture, test, and slaughter operation is preceded by efforts to reduce seroprevalence through vaccination. Given the already low risk levels of brucellosis infection achievable by separation of bison and cattle and by cattle management actions, the direct benefits of these actions relative to the first set of objectives are small relative to the costs. The only quantifiable benefits are nonmarket, in that some individuals may value knowing that bison are brucellosis free. These values have been estimated as discussed in "Affected Environment."

The present value of these benefits depends on when they are realized (when zero seroprevalence is achieved). The NAS (1998) report suggests that not enough is known at present to achieve this in bison and the disease would also have to be controlled in elk. The NAS (1998) report provides some specific management examples from Custer State Park and Wind Cave National Park where a herd-wide capture, test, and slaughter operations was used to control brucellosis in bison. This data suggests that achieving zero seroprevalence would take 10 and 20 years under alternatives 5 and 6 respectively, even where the number of bison and the setting were similar to a commercial ranching operation. These estimates have been used to compute a present value to benefits — implicitly discounting for both time and risk. A herd-wide capture, test, and slaughter operation similar to alternative 6 does not achieve zero prevalence in the planning period. The finding is that the direct benefits of these actions are quite small relative to costs, and the costs are also about double the estimated nonmarket benefits. The estimated nonmarket benefits are only based on the values attributable to Yellowstone National Park visitors and regional (Idaho, Montana, and Wyoming) residents. If reliable estimates were developed for the national population, the estimated nonmarket benefits would likely exceed costs. However, given that most survey respondents opposed herd-wide vaccination and slaughter, there are likely also considerable values associated with not having such a vaccination program. Information related to nonmarket benefits for vaccination would require further research.

Viable Population of Wild Bison. Three actions have been proposed related to this objective. The bison population size and range is less of an action than an outcome measure or constraint. The other two actions, bison management on public lands and acquiring additional wildlife habitat, in themselves have only a small impact on total bison populations. The upper limit to the number of bison allowed outside the park between, for example, alternative 1 and the modified preferred alternative, is only 150 to 300 versus 400. Most of the acquired habitat is north of Reese Creek, which is expected to support an additional 100 bison. None of the alternatives considered allows for bison populations approaching levels that would threaten herd viability. Accordingly, the direct benefits of achieving this objective have not been quantified.

Nonmarket benefits for acquiring winter range have been estimated, as discussed in "Affected Environment." Acquisition is proposed at several levels that vary with each alternative. The first level uses a total budget of $29 million in the *Draft Environmental Impact Statement* and was primarily intended to purchase the Royal Teton Ranch and possibly other lands north of Reese Creek. The lands targeted in this budget have now been acquired; these costs are sunk costs and do not appear as costs in tables 64–72. The nonmarket present value of benefits of this action is estimated at $4.2 million, assuming that the lands begin to serve their purpose as winter range in the year 2002. A higher level of acquisition has also been proposed (total budget of $43 million or $15 million net of the sunk costs). The benefits of this increment of winter range has not been estimated. It appears that neither of these levels of acquisition would be justified based on nonmarket values attributable to Yellowstone National Park visitors and regional (Idaho, Montana, and Wyoming) residents. However, if reliable estimates were developed for the national population, the estimated nonmarket benefits would likely exceed costs.

Research. An extensive research agenda is described in appendix D. However, the only action related to research listed in any of the alternatives is wildlife/winter-use monitoring related to winter road grooming. The costs of this monitoring is relatively low. The benefits have not been quantified.

Direct Benefits and Costs of the Objectives Under Each Alternative

The set of actions listed in table 64 and table 12 could be combined in a nearly endless number of permutations. The eight alternatives identified in this environmental impact statement are a subset of the possible combinations. In tables 65 through 72, benefits and costs for each of the eight alternatives are identified relative to the "without plan" case. (In a following section, net costs and benefits are summarized with reference to the "no-action" case, alternative 1). The overall benefit-cost evaluation of the various alternatives depends on whether the specific actions included in the alternative are, in themselves cost-effective.

The benefits and costs of alternative 1 are shown in table 65. This alternative relies on two of the more expensive approaches for protecting livestock from brucellosis (capture, test, and slaughter operations and vaccination programs for bison). Some of the costs shown also contribute to other objectives such as public safety and maintaining a viable population of wild bison, but have not been broken out. The basic finding is that the costs of this alternative ($7.5 million, present value) greatly exceed the net benefits — by an amount of about $5.5 million. This result is most sensitive to the benefit level of protecting livestock from brucellosis, which are estimated to be less than $1.5 million. Given the uncertainty in the latter estimate (which is dependent on the risk of an infection from bison to cattle), one can also note the required break-even level of risk needed to justify this level of expenditure. As can be noted in table 63, one would have to expect an occurrence of the disease every six years to have a break-even of direct costs and benefits.

TABLE 65: BENEFIT-COST OF BISON MANAGEMENT OBJECTIVES AND ACTIONS — ALTERNATIVE 1

Objective/Action	Direct Benefits and Costs			Present Value of Nonmarket Costs or Benefits	Net of Costs and Benefits
	Annual Costs	Present-Value Costs	Present-Value Benefits		
(A) Protect Livestock from Risk of Brucellosis					
1. Monitoring of bison	[1]	-	≤1,514,000	-	-
2. Agency shooting	[1]	-	≤1,514,000	-	-
3. Calfhood vaccination of cattle with RB51	N/A	-	≤1,514,000	-	-
4. Surveillance testing of cattle	N/A	-	-	-	-
5. Other cattle management actions	N/A	-	-	-	-
6. Modify national forest grazing allotments	N/A	-	-	-	-
7. Bison hunting	N/A	-	-	-	-

Table 65: Benefit-Cost of Bison Management Objectives and Actions — Alternative 1 *(continued)*

	Direct Benefits and Costs				
Objective/Action	**Annual Costs**	**Present-Value Costs**	**Present-Value Benefits**	**Present Value of Nonmarket Costs or Benefits**	**Net of Costs and Benefits**
8a. Capture, test, and slaughter operations at boundaries	525,800–657,800	5,310,000[2]	316,000	-	-
9. Vaccination of bison	330,500	2,143,000	-	-	-
10. Quarantine bison	N/A	-	-	-	-
11. Winter road grooming	N/A	-	-	-	-
(B) Public Safety, Private Property Damage					
12. Remove bison at landowner request	[1]	-	-	-	-
(C) Commit to Eliminating Brucellosis in Wildlife					
8b. Herd-wide capture, test, and slaughter operations — alternative 5	N/A	-	-	-	-
8c. Herd-wide capture, test, and slaughter operations — alternative 6	N/A	-	-	-	-
(D) Viable Population of Wild Bison					
13. Bison population range	N/A	-	-	-	-
14. Bison management on public lands	[1]	-	-	-	-
15. Acquire additional wildlife habitat	N/A	-	-	-	-
(E) Research					
16. Wildlife/winter-use monitoring	N/A	-	-	-	-
Totals	-	**7,532,900**	**1,991,900**	-	**(5,541,000)**

1. Not estimated or costs included in action 8a.

2. Net present value estimated using average of range of cost estimates. Capture facility cost of $359,500 are sunk costs and are not included.

Table 66: Benefit-Cost of Bison Management Objectives and Actions — Alternative 2

Objective/Action	Direct Benefits and Costs: Annual Costs	Direct Benefits and Costs: Present-Value Costs	Direct Benefits and Costs: Present-Value Benefits	Present Value of Nonmarket Costs or Benefits	Net of Costs and Benefits
(A) Protect Livestock from Risk of Brucellosis					
1. Monitoring of bison	44,000	400,700	≤ 1,514,000	-	-
2. Agency shooting	[1]	-	≤ 1,514,000	-	-
3. Calfhood vaccination of cattle with RB51	N/A	-	≤ 1,514,000	-	-
4. Surveillance testing of cattle	N/A	-	-	-	-
5. Other cattle management actions	N/A	-	-	-	-
6. Modify national forest grazing allotments	N/A	88,000	-	-	-
7. Bison hunting	N/A	-	-	-	-
8a. Capture, test, and slaughter operations at boundaries	264,000	2,471,294[2]	128,500	-	-
9. Vaccination of bison	330,500	2,143,000	-	-	-
10. Quarantine bison	N/A	-	-	-	-
11. Winter road grooming	55,000[3]	401,500	-	-	-
(B) Public Safety, Private Property Damage					
12. Remove bison at landowner request	[1]	-	-	-	-
(C) Commit to Eliminating Brucellosis in Wildlife					
8b. Herd-wide capture, test, and slaughter — alternative 5	N/A	-	-	-	-
8c. Herd-wide capture, test, and slaughter — alternative 6	N/A	-	-	-	-
(D) Viable Population of Wild Bison					
13. Bison population range	N/A	-	-	-	-

Table 66: Benefit-Cost of Bison Management Objectives and Actions — Alternative 2 (*continued*)

Objective/Action	Direct Benefits and Costs			Present Value of Nonmarket Costs or Benefits	Net of Costs and Benefits
	Annual Costs	Present-Value Costs	Present-Value Benefits		
14. Bison management on public lands	[1]	-	-	-	-
15. Acquire additional wildlife habitat	N/A	15,100,000[4]		4,144,700	
(E) Research					
16. Wildlife/winter-use monitoring	27,500	200,747	-	-	-
Totals	-	**20,805,241**	**1,642,500**	**4,144,700**	**(15,018,041)**

1. Not estimated or costs included in action 8a.
2. Includes relocating capture facility cost of $71,500.
3. Increased snowmobile enforcement in park.
4. $29.1 million to acquire level 1 winter range are sunk costs (lands already acquired). Cost for level 2 is based on alternative 2 total land acquisition cost estimate minus $29.1 million.

Table 67: Benefit-Cost of Bison Management Objectives and Actions — Alternative 3

Objective/Action	Direct Benefits and Costs			Present Value of Nonmarket Costs or Benefits	Net of Costs and Benefits
	Annual Costs	Present-Value Costs	Present-Value Benefits		
(A) Protect Livestock from Risk of Brucellosis					
1. Monitoring of bison	[1]	-	≤1,514,000	-	-
2. Agency shooting	[1]	-	≤1,514,000	-	-
3. Calfhood vaccination of cattle with RB51	N/A	-	≤1,514,000	-	-
4. Surveillance testing of cattle	N/A	-	-	-	-
5. Other cattle management actions	N/A	-	-	-	-

Table 67: Benefit-Cost of Bison Management Objectives and Actions — Alternative 3 *(continued)*

Objective/Action	Direct Benefits and Costs: Annual Costs	Direct Benefits and Costs: Present-Value Costs	Direct Benefits and Costs: Present-Value Benefits	Present Value of Nonmarket Costs or Benefits	Net of Costs and Benefits
6. Modify national forest grazing allotments	N/A	-	-	-	-
7. Bison hunting	66,000	481,800	389,200	175,100	-
8a. Capture, test, and slaughter operations at boundaries	419,100	3,878,800[2]	215,800	-	-
9. Vaccination of bison	330,500	2,143,000	-	-	-
10. Quarantine bison	447,500	4,282,100[3]	825,800	-	-
11. Winter road grooming	N/A	-	-	-	-
(B) Public Safety, Private Property Damage					
12. Remove bison at landowner request	[1]	-	-	-	-
(C) Commit to Eliminating Brucellosis in Wildlife					
8b. Herd-wide capture, test, and slaughter — alternative 5	N/A	-	-	-	-
8c. Herd-wide capture, test, and slaughter — alternative 6	N/A	-	-	-	-
(D) Viable Population of Wild Bison					
13. Bison population range	N/A	-	-	-	-
14. Bison management on public lands	[1]	-	-	-	-
15. Acquire additional wildlife habitat	N/A	-	-	4,144,727	-
(E) Research					
16. Wildlife/winter-use monitoring	N/A				
Totals	-	**10,785,700**	**2,944,800**	**4,319,827**	**(3,521,073)**

1. Not estimated or costs included in action 8a.
2. Includes cost to relocate capture facility of $66,000. Sunk facility cost of $132,000 is not included.
3. Includes one-time cost of quarantine facility of $715,000.

Table 68: Benefit-Cost of Bison Management Objectives and Actions — Alternative 4

Objective/Action	Direct Benefits and Costs			Present Value of Nonmarket Costs or Benefits	Net of Costs and Benefits
	Annual Costs	Present-Value Costs	Present-Value Benefits		
(A) Protect Livestock from Risk of Brucellosis					
1. Monitoring of bison	[1]	-	≤1,514,000	-	-
2. Agency shooting	[1]	-	≤1,514,000	-	-
3. Calfhood vaccination of cattle with RB51	N/A	-	≤1,514,000	-	-
4. Surveillance testing of cattle	N/A	-	-	-	-
5. Other cattle management actions	N/A	-	-	-	-
6. Modify national forest grazing allotments	N/A	-	-	-	-
7. Bison hunting	66,000	481,800	226,400	81,700	-
8a. Capture, test, and slaughter operations at boundaries	578,600	5,269,800[3]	419,600	-	-
9. Vaccination of bison	330,500	2,143,000	-	-	-
10. Quarantine bison	447,500	4,282,100[2]	1,166,300	-	-
11. Winter road grooming	N/A	-	-	-	-
(B) Public Safety, Private Property Damage					
12. Remove bison at landowner request	[1]	-	-	-	-
(C) Commit to Eliminating Brucellosis in Wildlife					
8b. Herd-wide capture, test, and slaughter operations — alternative 5	N/A	-	-	-	-
8c. Herd-wide capture, test, and slaughter operations — alternative 6	N/A	-	-	-	-

Table 68: Benefit-Cost of Bison Management Objectives and Actions — Alternative 4 (continued)

Objective/Action	Direct Benefits and Costs: Annual Costs	Direct Benefits and Costs: Present-Value Costs	Direct Benefits and Costs: Present-Value Benefits	Present Value of Nonmarket Costs or Benefits	Net of Costs and Benefits
(D) Viable Population of Wild Bison					
13. Bison population range	N/A	-	-	-	-
14. Bison management on public lands	[1]	-	-	-	-
15. Acquire additional wildlife habitat	N/A	-	-	-	-
(E) Research					
16. Wildlife/winter-use monitoring	N/A	-	-	-	-
Totals	-	12,176,700	3,326,300	81,700	(8,768,700)

1. Not estimated or costs included in action 8a.
2. Includes one-time cost of quarantine facility of $715,000.
3. Sunk facility cost of $379,500 are not included.

Table 69: Benefit-Cost of Bison Management Objectives and Actions — Alternative 5

Objective/Action	Direct Benefits and Costs: Annual Costs	Direct Benefits and Costs: Present-Value Costs	Direct Benefits and Costs: Present-Value Benefits	Present Value of Nonmarket Costs or Benefits	Net of Costs and Benefits
(A) Protect Livestock from Risk of Brucellosis					
1. Monitoring of bison	[1]	-	≤1,514,000	-	-
2. Agency shooting	[1]	-	≤1,514,000	-	-
3. Calfhood vaccination of cattle with RB51	N/A	-	≤1,514,000	-	-
4. Surveillance testing of cattle	N/A	-	-	-	-
5. Other cattle management actions	N/A	-	-	-	-
6. Modify national forest grazing allotments	N/A	-	-	-	-

Table 69: Benefit-Cost of Bison Management Objectives and Actions — Alternative 5 (*continued*)

Objective/Action	Direct Benefits and Costs: Annual Costs	Direct Benefits and Costs: Present-Value Costs	Direct Benefits and Costs: Present-Value Benefits	Present Value of Nonmarket Costs or Benefits	Net of Costs and Benefits
7. Bison hunting	N/A	-	-	-	-
8a. Capture, test, and slaughter operations at boundaries	N/A	-	-	-	-
9. Vaccination of bison	N/A	-	-	-	-
10. Quarantine bison	N/A	-	-	-	-
11. Winter road grooming	N/A	-	-	-	-
(B) Public Safety, Private Property Damage					
12. Remove bison at landowner request	[1]	-	-	-	-
(C) Commit to Eliminating Brucellosis in Wildlife					
8b. Herd-wide capture, test, and slaughter operations — alternative 5	2,636,760[3]	11,292,000[2]	376,400	1,695,150	-
8c. Herd-wide capture, test, and slaughter operations — alternative 6	N/A	-	-	-	-
(D) Viable Population of Wild Bison					
13. Bison population range	N/A	-	-	-	-
14. Bison management on public lands	[1]	-	-	-	-
15. Acquire additional wildlife habitat	N/A	-	-	-	-
(E) Research					
16. Wildlife/winter-use monitoring	N/A	-	-	-	-
Totals	-	**11,292,000**	**1,890,400**	**1,695,150**	**(7,706,450)**

1. Not estimated or costs included in action 8a.
2. Includes one-time capture facility cost of $1,056,000. Sunk capture facility cost of $132,000 not included.
3. Includes plowing of roads during first three years of plan at $575,960 per year.

Table 70: Benefit-Cost of Bison Management Objectives and Actions — Alternative 6

Objective/Action	Direct Benefits and Costs			Present Value of Nonmarket Costs or Benefits	Net of Costs and Benefits
	Annual Costs	Present-Value Costs	Present-Value Benefits		
(A) Protect Livestock from Risk of Brucellosis					
1. Monitoring of bison	[1]	-	≤1,514,000	-	-
2. Agency shooting	[1]	-	≤1,514,000	-	-
3. Calfhood Vaccination of cattle with RB51	N/A	-	≤1,514,000	-	-
4. Surveillance testing of cattle	N/A	-	-	-	-
5. Other cattle management actions	N/A	-	-	-	-
6. Modify national forest grazing allotments	N/A	-	-	-	-
7. Bison hunting	N/A	-	-	-	-
8a. Capture, test, and slaughter operations at boundaries	N/A	-	-	-	-
9. Vaccination of bison	N/A	-	-	-	-
10. Quarantine bison	N/A	-	-	-	-
11. Winter road grooming	N/A	-	-	-	-
(B) Public Safety, Private Property Damage					
12. Remove bison at landowner request	[1]	-	-	-	-
(C) Commit to Eliminating Brucellosis in Wildlife					
8b. Herd-wide capture, test, and slaughter operations — alternative 5	N/A	-	-	-	-
8c. Herd-wide capture, test, and slaughter operations — alternative 6	2,132,560–2,678,160	9,931,357[2]	411,600	0[3]	-

Table 70: Benefit-Cost of Bison Management Objectives and Actions — Alternative 6 *(continued)*

Objective/Action	Direct Benefits and Costs: Annual Costs	Direct Benefits and Costs: Present-Value Costs	Direct Benefits and Costs: Present-Value Benefits	Present Value of Nonmarket Costs or Benefits	Net of Costs and Benefits
(D) Viable Population of Wild Bison					
13. Bison population range	N/A	-	-	-	-
14. Bison management on public lands	1	-	-	-	-
15. Acquire additional wildlife habitat	N/A	-	-	-	-
(E) Research					
16. Wildlife/winter-use monitoring	N/A	-	-	-	-
Totals	-	**9,931,357**	**1,925,600**	**0**	**(8,005,757)**

1. Not estimated or costs included in action 8a.
2. Includes one-time capture facility cost of $165,000 during phase 1 and $792,000 during phase 2. Sunk capture facility cost of $132,000 is not included.
3. A one-time nonmarket benefit of $3,568,039 would be realized 22 years after initiation of the plan, but this would be beyond the 15-year horizon of the cost/benefit analysis.

Table 71: Benefit-Cost of Bison Management Objectives and Actions — Alternative 7

Objective/Action	Direct Benefits and Costs: Annual Costs	Direct Benefits and Costs: Present-Value Costs	Direct Benefits and Costs: Present-Value Benefits	Present Value of Nonmarket Costs or Benefits	Net of Costs and Benefits
(A) Protect Livestock from Risk of Brucellosis					
1. Monitoring of bison	1	-	≤1,514,000	-	-
2. Agency shooting	1	-	≤1,514,000	-	-
3. Calfhood vaccination of cattle with RB51	-	-	≤1,514,000	-	-
4. Surveillance testing of cattle	-	-	-	-	-
5. Other cattle management actions	Unknown	-	-	-	-
6. Modify national forest grazing allotments	N/A	-	-	-	-

Table 71: Benefit-Cost of Bison Management Objectives and Actions — Alternative 7 *(continued)*

	Direct Benefits and Costs				
Objective/Action	Annual Costs	Present-Value Costs	Present-Value Benefits	Present Value of Nonmarket Costs or Benefits	Net of Costs and Benefits
7. Bison hunting	66,000	481,800	185,700	58,400	-
8a. Capture, test, and slaughter operations at boundaries	963,500	8,829,400[4]	475,400	-	-
9. Vaccination of bison	330,500	2,142,800	-	-	-
10. Quarantine bison	447,500	4,372,600[3]	1,064,140	-	-
11. Winter road grooming	N/A	-	-	-	-
(B) Public Safety, Private Property Damage					
12. Remove bison at landowner request	[1]	-	-	-	-
(C) Commit to Eliminating Brucellosis in Wildlife					
8b. Herd-wide capture, test, and slaughter operations — alternative 5	N/A	-	-	-	-
8c. Herd-wide capture, test, and slaughter operations — alternative 6	N/A	-	-	-	-
(D) Viable Population of Wild Bison					
13. Bison population range	N/A	-	-	-	-
14. Bison management on public lands	[1]	-	-	-	-
15. Acquire additional wildlife habitat	Not estimated	[2]	4,144,700	-	-
(E) Research					
16. Wildlife/winter-use monitoring	5,500	50,100	-	-	-
Totals	-	**15,822,800**	**3,239,240**	**4,203,100**	**(8,380,460)**

1. Not estimated or costs included in action 8a.
2. Sunk costs of 27.1 million have already been spent.
3. Includes one-time cost of quarantine facility of $715,000.
4. Includes one-time cost of relocating capture facility of $66,000. Sunk facility costs of $132,000 not included.

Table 72: Benefit-Cost of Bison Management Objectives and Actions — the Modified Preferred Alternative

	Direct Benefits and Costs			Present Value of	
Objective/Action	Annual Costs	Present-Value Costs	Present-Value Benefits	Nonmarket Costs or Benefits	Net of Costs and Benefits
(A) Protect Livestock from Risk of Brucellosis					
1. Monitoring of bison	[1]	-	≤1,514,000	-	-
2. Agency shooting	[1]	-	≤1,514,000	-	-
3. Calfhood vaccination of cattle with RB51	N/A	-	≤1,514,000	-	-
4. Surveillance testing of cattle	N/A	-	-	-	-
5. Other cattle management actions	Unknown	-	-	-	-
6. Modify national forest grazing allotments	N/A	-	-	-	-
7. Bison hunting	N/A	-	-	-	-
8a. Capture, test, and slaughter operations at boundaries	963,500	8,775,500[3]	475,400	-	-
9. Vaccination of bison	330,500	2,142,800	-	-	-
10. Quarantine bison	447,500	4,372,600	1,796,300	-	-
11. Winter road grooming	N/A	-	-	-	-
(B) Public Safety, Private Property Damage					
12. Remove bison at landowner request	[1]	-	-	-	-
(C) Commit to Eliminating Brucellosis in Wildlife					
8b. Herd-wide capture, test, and slaughter operations — alternative 5	N/A	-	-	-	-
8c. Herd-wide capture, test, and slaughter operations — alternative 6	N/A	-	-	-	-

Table 72: Benefit-Cost of Bison Management Objectives and Actions — the Modified Preferred Alternative *(continued)*

Objective/Action	Direct Benefits and Costs: Annual Costs	Present-Value Costs	Present-Value Benefits	Present Value of Nonmarket Costs or Benefits	Net of Costs and Benefits
(D) Viable Population of Wild Bison					
13. Bison population range	N/A	-	-	-	-
14. Bison management on public lands	[1]	-	-	-	-
15. Acquire additional wildlife habitat	Not estimated	[2]	4,144,700	-	-
(E) Research					
16. Wildlife/winter-use monitoring	5,500	50,100	-	-	-
Totals	-	**15,341,000**	**3,785,700**	**4,144,700**	**(7,410,600)**

1. Not estimated or costs included in action 8a.

2. Sunk costs of 27.1 million have already been spent.

3. Sunk capture facility costs of $379,000 are not included.

Alternative 2 (table 66) has lower costs for direct bison management than any other alternative, reflecting that in later years border and population control is by agency shooting. However, the alternative does include vaccination program(s). The alternative also includes a large budget for additional winter range acquisition. Costs again exceed benefits. If this alternative did not include vaccination and acquisition of additional winter range, it would be the closest to being justified on the grounds of benefit-cost than any of the other alternatives.

Alternatives 3 and 4 include hunting, which is an approximately a break-even operation, but also includes expensive capture, test, slaughter, vaccination, and quarantine operations. Direct benefits of reducing the risk of brucellosis infection would have to be on the order of $8 million per year to justify the proposed costs. This would imply a brucellosis infection rate of about one every five years.

Alternatives 5 and 6 both have large costs associated with herd-wide capture, test, slaughter, and related vaccination operations. Costs greatly exceed direct benefits.

Alternative 7 has a high cost of capture, test, and slaughter operations, as well as vaccination and quarantine programs. The net of direct costs over direct benefits is about $12 million. One would have to expect an occurrence of brucellosis from bison infecting cattle at a rate of almost once every three years for benefits to equal costs.

The modified preferred alternative is similar to alternative 7 with respect to benefits and costs, but is just slightly less expensive. The small difference is due to the assumed greater number of bison coming out of quarantine (which affects the revenues or benefits from live disease-free bison available for distribution). However, the modified preferred alternative does add some modifications compared with alternative 7 that have not added to estimated costs and may cost-effectively contribute to the objectives. The modified preferred alternative adopts some management concepts from the NAS (1998) report, including adaptive management with respect to bison distribution and numbers and the concept of a buffer zone or management zone (comprised of the SMAs) on the perimeter of Yellowstone National Park. Other changes are responsive to many comments on the *Draft Environmental Impact Statement* suggesting that it is cost-effective to more actively manage cattle. The modified preferred alternative includes several such actions, including more surveillance testing of cattle, 100% voluntary (in its absence, mandatory) calfhood vaccination, and modification of turn-on dates on national forest allotments, as necessary, to ensure a 45-day separation of bison and cattle. Perceived risk is also addressed though the commitment of APHIS to consult with states threatening sanctions and convince those states that sanctions are unwarranted. With respect to the wild and free-roaming bison objective, the modified preferred alternative also has a somewhat higher population target (3,000) based on NAS (1998) findings regarding the level at which bison movement outside the park will most likely begin to occur.

The basic finding is that none of the alternatives is justified on direct benefit-cost grounds. These findings are not changed if one also incorporates nonmarket values. To justify the most expensive alternatives, one would have to assume risk levels for brucellosis infection in cattle from Yellowstone National Park bison that are implausible — on the order of once every three to five years. While the NAS (1998) report does not identify the risk of transmission, it does say that "it is too small to measure with accuracy." It is difficult to view a probability of occurrence of 20% to 33% as being "too small to measure."

Except for the "commit to eliminate brucellosis in wildlife" objective, it appears that it would be possible to construct a permutation of the listed actions that would satisfy the objectives and be at least close to passing a benefit-cost test. This would consist of something similar to the alternative 2 approach (controlling bison populations and distribution and the risk of brucellosis — except the vaccination of bison action) and the alternative 7 or the modified preferred alternative approach to actively managing cattle with regard to additional winter range. The cost-effective strategy is to make use of already acquired lands but not acquiring more, except possibly through easements.

Summary of Costs and Benefits by Alternative. Table 64 presents a summary of the action-specific costs and benefits detailed in tables 65–72. Table 73 shows a comparison of the net present value of costs and benefits by objective for each of the eight alternatives relative to the "without-plan" case. As discussed previously, objective B, "Public Safety, Private Property Damage," is not estimated as impacts to this objective are uncertain and likely to be minor.

A comparison of total net present value of costs and benefits, shown in table 73, shows that based on available data, none of the alternatives is justified on a benefit-cost basis. Alternative 3 comes the closest to being justified with a net present value of minus $3,521,073. Alternative 2 is the least attractive on a benefit-cost basis with an expected net cost over the life of the plan of $15,018,041 (This large loss is largely due to the proposed acquisition of additional bison winter range for $15.1 million).

Table 74 shows the information presented in table 73, but with reference to the costs and benefits of the "no-action" alternative of the current interim plan (alternative 1). Table 74 shows that among the seven action alternatives only alternative 3 is less costly (on a net benefit-cost basis) than the alternative 1 program. Alternative 2, with its large additional purchase of winter range, is the most costly relative to alternative 1, unless the additional winter range purchase is excluded.

Table 73: Net Present Value of Costs and Benefits by Alternative and Objective

Objective	Alt 1 (current)	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Modified Preferred Alternative
(A) Protect Livestock from Risk of Brucellosis	(5,541,000)	(3,861,994)	(7,665,800)	(8,768,700)	-	-	(12,535,160)	(11,505,200)
(B) Public Safety, Private Property Damage	-	-	-	-	-	-	-	-
(C) Commit to Eliminating Brucellosis in Wildlife	-	-	-	-	(7,706,450)	(8,005,757)	-	-
(D) Viable Population of Wild Bison	-	(10,955,300)	4,144,727	-	-	-	4,144,700	4,144,700
(E) Research	-	(200,747)	-	-	-	-	-	50,100
Totals	(5,541,000)	(15,018,041)	(3,521,073)	(8,758,700)	(7,706,450)	(8,005,757)	(8,380,460)	(7,410,600)

Table 74: Net Present Value of Costs and Benefits by Alternative and Objective — Differences from Alternative 1

Objective	Alt 1 (current)	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Modified Preferred Alternative
(A) Protect Livestock from Risk of Brucellosis	0	1,679,006	(2,124,800)	(2,227,700)	5,541,000	5,541,000	(6,994,160)	(5,964,200)
(B) Public Safety, Private Property Damage	0	-	-	-	-	-	-	-
(C) Commit to Eliminating Brucellosis in Wildlife	0	-	-	-	(7,706,450)	(8,005,757)	-	-
(D) Viable Population of Wild Bison	0	(10,955,300)	4,144,727	-	-	-	4,144,700	4,144,700
(E) Research	0	(200,747)	-	-	-	-	-	(50,100)
Totals	0	5,622,959	2,019,927	(3,217,700)	(2,165,450)	(2,464,757)	(2,839,460)	(1,869,600)

Social Value Impacts of Achieving the Objectives.

Surveys of Yellowstone National Park visitors and residents of the Greater Yellowstone Area, the three-state region (Idaho, Montana, and Wyoming), and national residents provide information on public acceptance of and attitudes toward some of the proposed actions. This information is detailed in "Affected Environment." Table 75 provides a summary.

Table 75: Social Values — For Those with an Opinion, Ratio of Agree: Disagree or Disagree: Agree on Attitude Statements

	Phone			Summer Visitor		Winter Visitor	
	Local	Regional	National	Resident	Nonresident	Resident	Nonresident
Access	2:1 agree	2:1 agree	1.3:1 agree	1.5:1 agree	1.4:1 agree	2.4:1 agree	4.7:1 agree
Disturb	2:1 agree	3:1 agree	9:1 agree	4.4:1 agree	6.4:1 agree	2.6:1 agree	3:1 agree
Graze	2:1 agree	2:1 agree	1.5:1 agree	1.6:1 agree	1.1:1 agree	1.2:1 agree	1.2:1 agree
Kill	1.7:1 agree	1.8:1 agree	1.6:1 agree	1:1 divided	1.2:1 agree	1.3:1 disagree	1.3:1 agree
Range	1:1 divided	1:1 divided	1:1 divided	1.4:1 agree	1.2:1 agree	2.2:1 agree	1.4:1 agree
Don't vaccinate	1.8:1 agree	2.2:1 agree	3:1 agree	-	-	-	-
Vaccinate	-	-	-	2.5:1 disagree	1.2:1 agree	2.7:1 disagree	1.3:1 disagree
Close road for bison	1.3:1 open	1.2:1 close	2.1:1 close	1:1 divided	1.4:1 close	-	2.2:1 open

Access: Visitors should have the opportunity to mechanized winter access into Yellowstone National Park.

Disturb: I am concerned about the possible disturbance of Yellowstone wildlife in the winter.

Grazing: Livestock grazing is an appropriate use of national forest lands around Yellowstone National Park.

Kill: It is appropriate to kill bison at park boundaries as necessary to protect domestic livestock.

Range: Yellowstone bison should be allowed to range onto public lands outside Yellowstone National Park.

Vaccinate: All bison in Yellowstone National Park should be rounded up and tested for disease then either slaughtered or vaccinated.

Don't vaccinate: All bison should be rounded up and tested for the disease rather then either slaughtered or vaccinated.

Close road for bison: Grooming the roads into Yellowstone National Park from West Yellowstone and Mammoth for over snow vehicles provides an easier winter route out of the park for bison. If roads were not groomed, more bison might remain in the park. Given this possibility, which of the following policies would you prefer?

One of the most challenging aspects of bison management is the issue of controlling animal numbers. All alternatives incorporate some form of lethal control; it is possible that even animals that are quarantined bison would be transferred to commercial operations and eventually slaughtered, although the details of how live bison are dispersed would be part of a future planning and NEPA process. Agency shooting is judged by the American Veterinary Medical Association to be an acceptable method of euthanasia (appendix F). Among the general public (Greater Yellowstone Area residents, regional residents, and national residents) and for those respondents who had an opinion, a majority (in a 1.6:1 to 1.8:1 ratio) agree "It is appropriate to kill bison at park boundaries as necessary to protect domestic livestock." Nonresident summer and winter visitors are less accepting of the notion (1.2:1 to 1.3:1) agree, while resident summer visitors are divided on the notion and winter resident visitors disagree in a 1.3:1 ratio.

On the issue of whether "Yellowstone bison should be allowed to range onto public lands outside Yellowstone NP [National Park]," the general public is divided across all subsamples. Park visitors, on the other hand, agree with this concept, with residents being more supportive of the idea (1.4:1 to 2.2:1) than nonresidents (1.2:1 to 1.4:1). However, all populations sampled agreed that "Livestock grazing is an appropriate use of national forest lands around Yellowstone NP [National Park]" The general public was strongly supportive of this statement, with the visitor population being less supportive, but still agreeing.

The visitor population surveys included a statement intended to test support for herd-wide capture, test, and slaughter operations such as proposed in alternative 5 and 6. With respect to the statement "All bison in Yellowstone NP [National Park] should be rounded up and tested for the disease then either slaughtered or vaccinated," resident summer and winter visitors were in strong disagreement (2.5:1 to 2.7:1) as were winter nonresident visitors (1.3:1 disagree). Summer nonresident visitors provided mild support for the concept (1.2:1) but the percentage agreeing (35.4%) was less than the percentage who were neutral or did not know (36.4%). In the general public surveys, a slightly different statement was used: "All bison in Yellowstone National Park should be rounded up and tested for the disease rather than either slaughtered or vaccinated." A strong majority of respondents agreed with this statement (1.8:1 to 3:1). These findings are generally consistent with the opinion offered in the NAS (1998) report that "Neither depopulation nor a test-and-slaughter program alone is likely to be publicly acceptable," although the NAS report does suggest an approach similar to alternative 6 (vaccination first) may be acceptable. On this issue the NAS report also suggests that administering a brucellosis-elimination program similar to that used for domestic livestock could be inconsistent with the wild free-ranging objective "..rounding up has the consequence of some artificial selection for domestication because wildness and intractability, salient traits in wild bison, are not disfavored. Those are important traits to retain in YNP [Yellowstone National Park] bison, one of the few herds where it is feasible to maintain natural behavior, so rounding up is not likely to be acceptable."

Public attitudes were also examined with regard to the issue of mechanized access to Yellowstone National Park in the winter. All subsamples agreed (particularly winter visitors) with the statement "Visitors should have the opportunity for mechanized winter access into Yellowstone NP [National Park]." Nonetheless, all subsamples also agreed to an even greater extent (table 75) that: "I am concerned about the possible disturbance of Yellowstone wildlife in the winter." Respondents were faced with the specific choice of trading off access with concern for wildlife, as expressed in the following question, "Grooming the roads into Yellowstone National Park from West Yellowstone and Mammoth for over snow vehicles provides an easier winter route out of the park for bison. If roads were not groomed, more bison might remain in the park. Given this possibility, which of the following policies would you prefer?" The choices were "the currant policy that allows for winter access" and "to close motorized winter access" or "not sure." Summer nonresident visitors favored closing roads (1.4:1) as did regional and national residents (1.2:1 and 2.1:1, respectively). Summer resident visitors were evenly divided on the issue, while winter visitors favored having access (2.2:1) as did local phone respondents (1.3:1).

REGIONAL ECONOMIC IMPACTS OF ACHIEVING THE OBJECTIVES

Changes in sales of goods and services for export outside the affected area or sales to nonresident tourism would have an economic impact on the regional economy. In addition to the direct change in expenditures in an export-base framework, there would be multiplier effects on other area businesses.

With regard to livestock lease operations that would be converted to other uses, there would be a reduction in the lease payments coming into the region. There would also be multiplier effects of lost revenue to the local economy, for example, through equipment and ranch supply purchases. With regard to tourism, changes in the number of nonresident tourists coming to the affected area would also result in expenditure changes and multiplier effects on the regional economy. Similarly, expenditures by hunters would impact the regional economy. Table 76 details those regional economic impacts that have been estimated under each of the alternatives.

Changes in expenditures in the region by governmental agencies would also impact the overall level of economic activity in the regional economy. For this reason, table 76 includes changes in bison management costs, as well as changes in road grooming costs.

FINANCIAL IMPACTS

The various alternatives would have financial impacts on a number of governmental entities, including changes in county and state tax revenues, changes in entry fees to Yellowstone National Park, changes in hunter fees to the Montana Department of Fish, Wildlife, and Parks, and changes in grazing fees to the U.S. Forest Service. These changes would all likely be relatively small in the context of the overall impacts of the alternatives and in general, have not been quantified. However, as an example, changes in county tax payments due to changes in livestock operations might be estimated by multiplying the per capita tax rate by the number of livestock grazed in the SMAs. Even if the livestock were put elsewhere in the county and state, they would displace other livestock, assuming all available animal unit months in the county and state were currently being used. There would be no loss in property taxes on private land if the land was acquired and managed by the Montana Department of Fish, Wildlife, and Parks or an easement was placed on the property. However, if the land was acquired by a federal agency, there would be potential for losses in property taxes.

Hunter fees to the Montana Department of Fish, Wildlife, and Parks were quantified. These are estimated to be $53,320 for alternative 3, $31,016 for alternative 4, and $25,440 for alternative 7.

Table 76: Differences between Current and Alternative-Specific Annual Expenditure Impacts

	Current Values	Alt 1[1]	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Modified Preferred Alternative
Winter tourism expenditures[2]	Not estimated	0	13,750,000	0	0	13,750,000	13,750,000	0	0
Hunter expenditures	0	0	0	32,900	15,380	0	0	10,896	0
Livestock operations	$150,851	0	(150,851)	(36,627)	0	0	0	(36,627)	(36,627)
Bison management expenses[4]	$922,300	0	(201,300)	340,800	500,300	1,714,460	1,483,060	890,700	824,700
Trail grooming expenses[3]	$17,250	0	17,250	0	0	0	0	0	0

1. Alternative 1 assumes continuation of current values.
2. Alternatives 5 and 6 winter tourism expenditure losses are for years with highest impact and are not constant across the 15 years of the plan. Alternative 5 winter expenditure reductions are for years 1–4. Alternative 6 would have winter expenditure reductions similar to those under alternative 2 in the years 1–10 and similar to alternative 5 in years 11–14.
3. Assumes average of high and low estimates for winter road grooming.
4. Assumes years of highest spending impact.

DEFINITIONS OF LINE ITEMS

Winter tourism expenditures: Spending by winter visitors from outside the area on goods and services within the area.

Hunter expenditures: Spending in the Greater Yellowstone Area by hunters hunting bison in the area

Livestock operations: Lost value of grazing leases on public and private land.

Bison management expenses: The direct expenditures by federal and state agencies to implement bison management under the alternatives.

Trail grooming expenses: The cost to the Yellowstone National Park of grooming winter snowmobile and snowcoach trails.