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## CHAPTER 4. ENVIRONMENTAL CONSEQUENCES -- PART A

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INTRODUCTION

This chapter summarizes and compares the potential effects of each alternative on the physical environment, biological resources, social and cultural parameters and resources, and economic factors. The chapter also summarizes the ability of the U.S. Fish and Wildlife Service, the National Park Service, and other agencies to meet legal responsibilities under each alternative, as well as the consistency of each alternative with wildlife management principles. Existing conditions of the environment, biological resources, and socioeconomic factors are described in Chapter 3, and care was taken to ensure that the elements of each major issue identified in Chapter 1 were addressed in the analysis contained in this chapter. The analysis of potential effects on the environment, biological resources, and socioeconomic factors was used in assessing the effects of each alternative on the ability of the agencies to meet legal requirements.

LEVEL OF DETAIL

The potential effects of elk and bison management on some resources are described in detail for several reasons. First, the plan for managing elk and bison on the National Elk Refuge and in Grand Teton National Park is being completed before the preparation of the refuge’s comprehensive conservation plan and the park’s new general management plan. Elk and bison numbers and distributions and their management on the refuge and in the park have substantial and far-reaching effects on some resources. An in-depth analysis was undertaken to ensure that decision-makers and the public would have an understanding of potential ramifications that elk and bison management would have on the range of management options to be evaluated in the future comprehensive conservation and general management plans for the two areas. For example, the refuge has specific responsibilities for providing habitat for breeding birds, as well as a refuge and grazing habitat for other ungulates (in addition to elk). Elk and bison management on the refuge has had considerable effects on the ability of the U.S. Fish and Wildlife Service to accomplish these purposes. Therefore, particular attention was paid to the potential effects on birds and large ungulates.

Furthermore, this planning document/environmental impact statement provides more than programmatic coverage for elk and bison management. The level of analysis in this chapter is sufficient to allow several management actions to be carried out without having to complete additional environmental analyses (e.g., environmental assessments) prior to implementation.

Another factor that has increased the complexity of the analysis is the number of geographic areas and jurisdiction in which impacts could potentially occur, including the refuge, the park, the national forest, Yellowstone National Park, BLM lands in Jackson Hole and the Green River basin, and private lands in the Jackson Hole area and Green River basin.

LEVEL OF IMPACTS

The degree of impact can be quantified in some cases, such as when modeled estimates were used and when extensive monitoring or research results provided pertinent numeric information. However, in most situations only qualitative descriptions of impacts are available. The following definitions are applied throughout the environmental impact statement, except where otherwise noted:

- **Negligible** — The impact would be at the lower levels of detection (<5% change).
- **Minor** — The impact would be detectable (a change of 5%–24%).
- **Moderate** — The impact would be readily apparent, and it would have the potential to become major (a change of 25%–50%).
- **Major** — The impact would be severe, or if beneficial, it would have exceptional beneficial effects (a change of >50%).

ASSUMPTIONS

Assessments were based on a variety of information, including meetings and other communications with natural resource and other professionals, published scientific information, agency
reports, and computer modeling, among other sources.

The following assumptions have been made in the analysis presented in this chapter:

- Funding and personnel would be sufficient to implement any alternative selected. This does not constitute a commitment for funding, and future budgets could change.
- Monitoring programs would be implemented and monitoring activities would be conducted a minimum of once every 5 years, and adjustments or revisions would be made to management as indicated by evaluations (but within the scope of the particular alternative).
- Standard operating procedures would be followed.
- The bison and elk management plan would be revisited at 15 years.

**SHORT-TERM VERSUS LONG-TERM EFFECTS**

Potential impacts are discussed in relation to short-term and long-term time frames. Short-term effects cover those that would be apparent within 15 years of implementing an alternative. Long-term effects are those that would either continue from the short term beyond the 15-year timeframe into the next 30 or more years or that would not be expected to occur until 15–30 years or longer.

**RESOURCE IMPAIRMENT IN THE NATIONAL PARK**

The purpose of the National Park System, as established by the NPS Organic Act and reaffirmed by the 1970 General Authorities Act, as amended, begins with a mandate to conserve park resources and values. NPS managers must seek ways to avoid, or to minimize to the greatest degree practicable, adverse impacts on park resources and values. However, the laws do give NPS managers discretion to allow adverse impacts to park resources and values when necessary and appropriate to fulfill the purposes of a park, as long as the impacts do not constitute impairment of the affected resources and values. Congress has given the National Park Service management discretion to allow certain impacts within parks, limited by the statutory requirement that park resources and values must be left unimpaired, unless a particular law directly and specifically provides otherwise. The prohibited impairment is an impact that, in the professional judgment of the responsible NPS manager, would harm the integrity of park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values. An impact to any park resource or value may constitute impairment. An impact would be more likely to constitute impairment to the extent it affects a resource or value whose conservation is:

- necessary to fulfill specific purposes identified in the establishing legislation or proclamation of the park;
- key to the natural or cultural integrity of the park or to opportunities for enjoyment of the park; or
- identified as a goal in the park’s general management plan or other relevant NPS planning documents.

A determination on impairment is included in the impact analysis section for all impact topics relating to the resources and values of Grand Teton National Park and John D. Rockefeller, Jr., Memorial Parkway.

**BASELINE CONDITIONS AND THE NO-ACTION ALTERNATIVE**

The effects of alternatives are compared to baseline conditions and to the No-Action Alternative (Alternative 1). Baseline conditions, as described below, represent the conditions that have resulted from the current management program up through the signing of the Record of Decision.

- Since winter 2001–2 the Jackson elk herd has numbered approximately 13,000 animals, which is above the WGFD herd objective. The Wyoming Game and Fish Department is actively working to reduce elk numbers in the Jackson elk herd and the decision to adopt 11,000 as a herd objective and to actively manage toward this number is independent of the decision being made in this planning process. Therefore, the potential
impacts of reducing the herd from existing numbers (an estimated 12,855 in February 2006) to the herd objective are not addressed in the sections addressing potential effects of the alternatives. Rather, they are addressed in cumulative impacts sections.

• The number of elk wintering on the refuge has fluctuated between 5,000 and 7,500 animals over the past six years, which is consistent with the 1974 cooperative agreement between the U.S. Fish and Wildlife Service and the Wyoming Game and Fish Department that established a maximum of 7,500 elk for the refuge. Monitoring results indicate that elk numbers have not dropped below 5,000 on the refuge in many decades.

• In 2006 the Jackson bison herd numbered about 1,000 animals and under present conditions will continue to increase.

• Wildlife populations, habitat, and socio-economic factors fluctuate over time. Therefore, information from the past 5–20 years was used in the analysis where possible to better represent the average or range of baseline conditions.

Therefore, baseline conditions are slightly different than the affected environment described in Chapter 3.

Conditions that would occur under Alternative 1 involve a continuation of baseline conditions into the future. Although some conditions would remain the same over the long term under Alternative 1, other conditions (e.g., acreage of aspen on the refuge) might change from baseline conditions.

CUMULATIVE EFFECTS

At the end of each impact topic (the physical environment, habitats, wildlife, human health and safety, and social and economic conditions) the anticipated cumulative effects of each alternative and reasonably foreseeable actions are disclosed. The anticipated direct effects of the reasonably foreseeable activities are discussed first, followed by a discussion of anticipated cumulative effects of each alternative and reasonably foreseeable actions. Reasonably foreseeable actions are described in Chapter 1. Existing conditions, ongoing management practices, and past events/activities are discussed in the Chapter 3, as well as this chapter.

The cumulative effects discussion focuses on four broad categories of reasonably foreseeable actions:

• transportation improvements
• federal land management activities
• Snake River restoration activities
• population growth and private land development
IMPACTS ON THE PHYSICAL ENVIRONMENT

SOILS

Potential effects on soils would primarily result from farming and irrigation practices on the National Elk Refuge, the restoration of native vegetation in Grand Teton National Park, and possibly changes in numbers and distribution of elk and bison on the refuge and in the park. Potential effects of farming and irrigation practices were obtained from the Irrigation System Rehabilitation Plan Environmental Assessment (USFWS 1998). Assessments of the potential effects of elk and bison management on refuge and park soils were based on Stottlemeyer et al. (2003), with supplementary information from other sources.

IMPACTS OF THE ALTERNATIVES

Alternative 1

Analysis

Soils on up to 2,400 acres in cultivated fields on the refuge would continue to be disturbed to a depth of 6 inches by disk harrowing. Resulting soil erosion would be minimal because fields are nearly level. From 700 to 2,000 acres would be flood irrigated in any given year. Annual harrowing where feces have built up during winter feeding operations would continue to disturb the soil surface, but effects would be negligible.

Current flood irrigation practices would likely continue to cause soil nutrient depletion due to a relatively thin topsoil and cobbly or gravelly soils below. Fertilizers would be applied infrequently. As compared to a situation in which elk and bison were absent or at low densities, large numbers of elk and bison during fall and winter could contribute to inorganic nitrogen at levels that are negligibly to moderately higher, and to nitrogen mineralization rates that are negligibly to moderately higher (Stottlemeyer et al. 2003). Nitrogen mineralization produces highly usable nitrogen for plants. These effects would continue and would increase over the long term due to the growing bison population, and the effects would primarily occur in cultivated fields and some sagebrush shrublands, native grasslands, and wet meadows on the refuge and immediately to the east. Thus, urination and defecation by elk and bison in cultivated fields could offset, to some degree, the nutrient depletion caused by flood irrigation.

Heavy equipment used for feeding operations would compact soils to a negligible degree because most of the feeding occurs when the ground is frozen and feeding sites change daily. Large numbers of elk and bison could be compacting soils to a minor to moderate extent (Stottlemeyer et al. 2003), and this would continue.

In Grand Teton National Park relatively high concentrations of bison during the spring and summer could compact soils in localized areas, and they could be contributing to inorganic nitrogen levels and nitrogen mineralization rates that are negligibly to moderately higher. As the bison population continues to grow, localized impacts to soils could become problematic.

In Bridger-Teton National Forest localized areas of soil erosion could occur on winter elk range, but soil erosion does not appear to be a problem away from the state feedgrounds and major migration routes to these sites (USFS 2003b).

Conclusion

Up to 2,400 acres of cultivated fields on the National Elk Refuge would continue to be disturbed by disking, with negligible impacts. Continued flood irrigation would continue to deplete soil nutrients, which could be offset to some degree by waste products from bison and elk.

An unlimited number of bison in Grand Teton National Park over the long term could result in the most impacts to soils, even though effects would be negligible. Potential effects on soils in the park would not result in impairment to park resources.

Alternative 2

Analysis

Restoring native vegetation would require limited disking in cultivated fields, resulting in short-term, adverse impacts on these fields. Continuing
flood irrigation for several years until native vegetation became established would result in limited nutrient depletion, as described for Alternative 1. Once native vegetation was established, farming and flood irrigation would cease, and resulting impacts to soils would cease. The long-term accumulation of vegetative matter at the surface of the soil and the lack of disking and flood irrigation would eventually allow soils to build in a natural manner.

Moderate reductions in elk and bison numbers and densities and changes in their distribution and movements on the refuge, due to phasing out winter feeding and irrigation and eliminating hunting on the refuge, could reduce inorganic nitrogen levels and nitrogen mineralization rates. Effects would be nonexistent to negligible for several years, but would become more apparent after winter feeding and flood irrigation were eliminated. Even though fewer animals would be present, nitrogen and other nutrients would no longer be depleted by flood irrigation.

After the initial restoration efforts, no heavy equipment would be used in currently cultivated areas. This would have a negligible beneficial effect on soil compaction. Moderate reductions in elk and bison numbers and densities and increased movements throughout the refuge would reduce soil compaction, as compared to both baseline conditions and Alternative 1.

In Grand Teton National Park localized compaction of soils by bison would be lessened due to fewer bison inhabiting the park, as compared to baseline conditions and Alternative 1. This could negligibly reduce soil compaction, inorganic nitrogen levels, and nitrogen mineralization rates.

Restoring native vegetation on 4,500 acres of agricultural lands in the park would involve disking, which would temporarily disturb soils. However, these lands had been repeatedly plowed and disked in the past, and this additional work would have negligible adverse impacts. Resulting soil erosion would be negligible because most fields are nearly level or have very minimal slope.

Larger numbers of elk wintering in the Gros Ventre River drainage, Buffalo Valley, and other areas in Jackson Hole could increase soil erosion in localized areas. Potentially larger numbers of elk on state feedgrounds in the Gros Ventre River drainage, lower Hoback River, and south of Jackson could increase adverse impacts to soils adjacent to the feedgrounds. However, the overall effects on soils in the Jackson Hole area would be negligible and might be partially offset by treatments of aspen, Douglas-fir, sagebrush, and other habitats in the national forest to improve habitat conditions and increase the distribution of elk during winter. Habitat improvement would have negligible impacts on soils due to the temporary potential for soil erosion. It is not known whether soil erosion caused by bison grazing on south and southwest-facing slopes immediately east of the refuge would increase or decrease, although bison numbers would be lower compared to Alternative 1.

If large numbers of elk began migrating to the Green River basin and the Red Desert, soil erosion in localized areas could increase due to hoof action and higher levels of grazing and browsing pressure on vegetation that is already heavily grazed and browsed in some areas.

Conclusion

Restoring native vegetation would result in one-time, short-term impacts in cultivated fields on the refuge and agricultural lands in the park. Soils would benefit more than under any other alternative due to the restoration of native vegetation and the subsequent lack of disturbance. Potential effects on soils in the park would not result in impairment to park resources.

Alternative 3

Analysis

Continuing farming and flood irrigation under Option A of the habitat management program would have similar impacts to those described under Alternative 1. Soil erosion associated with disking would be minimal, and flood irrigation would likely continue to cause nutrient depletion in soils, as described under Alternative 1.

Under Option B the potential effects on soils in the cultivated portions of the refuge would be similar to those estimated for Alternative 2 due to similarities in the restoration of native vegetation and the elimination of farming and flood irrigation. Soil erosion would decline by a negligible
degree, nutrients would no longer be depleted due to flood irrigation, and disking would not turn over the soil and would allow it to develop naturally.

Substantially reducing elk numbers and maintaining bison numbers near the existing level could reduce inorganic nitrogen levels and nitrogen mineralization rates, similar to Alternative 2. Effects would be non-existent to negligible for several years, but would become more apparent after winter feeding was reduced to severe winters only. Under Option B reduced levels of inorganic nitrogen and the rate of nitrogen mineralization would be partially offset by the elimination of flood irrigation because flood irrigation would no longer deplete these and other nutrients.

With a lower number and density of elk and reduced use of heavy equipment for feeding elk and bison, soil compaction would be reduced compared to Alternative 1. Compaction would be further reduced under Option B with the elimination of farming practices, although tractors and other equipment would be used in the short term to restore native vegetation.

In Grand Teton National Park soil conditions in areas grazed by bison would remain similar to baseline conditions, but soil compaction, inorganic nitrogen levels, and nitrogen mineralization rates would be negligibly lower than under Alternative 1 (bison numbers would continue to grow under Alternative 1). In the short term activities to restore native vegetation to 4,500 acres of agricultural lands in the park would result in negligible adverse effects, similar to Alternative 2. In the long term soil conditions would be essentially unaffected.

Greater winter use by elk of Bridger-Teton National Forest and associated state feedgrounds could increase soil erosion in localized areas, as described in Alternative 2. Also, habitat treatments in the national forest could temporarily increase soil erosion, but enhanced habitat conditions would more than offset this effect. If large numbers of elk began migrating to the Green River basin and the Red Desert, localized areas of increased soil erosion could occur, as discussed in Alternative 2. Soil erosion caused by bison grazing on south and southwest-facing slopes immediately east of the refuge could increase compared to baseline conditions. Although bison numbers would not increase beyond baseline numbers, major reductions in winter feeding on the refuge could result in more bison using these slopes during winter.

**Conclusion**

Up to 2,400 acres of cultivated fields on the National Elk Refuge would continue to be disturbed by disking under Option A, with negligible impacts. Continued flood irrigation would continue to deplete soil nutrients, which could be offset to some degree by waste products from bison and elk. An estimated 1,000 bison in Grand Teton National Park over the long term could result in the most impacts to soils, even though effects would be negligible.

Stopping farming on the refuge under Option B and restoring native vegetation on the refuge and in the park would result in one-time, short-term impacts in affected areas, the same as Alternative 2. Soils would benefit more than under any other alternative due to the restoration of native vegetation and the subsequent lack of disturbance. Potential effects on soils in the park would not result in impairment to park resources.

**Alternatives 4, 5, and 6**

**Analysis**

Effects of farming practices on refuge soils would be similar to the effects described in Alternative 1. Soil erosion associated with disking would be minimal because cultivated fields are nearly level. Up to 2,400 acres would continue to be cultivated (similar to Alternative 1). The negligible effects of harrowing after the winter feeding season would continue as described under Alternative 1.

Approximately 61,106 feet of water pipeline would be installed. However, 40% of this distance (about 24,547 feet) would occur within cultivated fields, so no additional impacts to soils would occur. Laying the remaining 38,591 feet of pipeline within a 10-foot-wide right-of-way would result in soil disturbance to an estimated 9.4 acres. The pipeline would be buried several feet in places. A portion of the pipeline (2,030 feet) between the Flat Creek inlet and the Chambers project area would cross USFS land, resulting in the disturbance of ap-
Impacts on the Physical Environment: Soils

Approximately 0.5 acre in Bridger-Teton National Forest. The flood irrigation system for other fields would be improved. All disturbed soils along the pipeline right-of-way would be immediately replaced and reseeded to reduce the likelihood of soil erosion. Soil disturbance associated with pipeline construction and flood irrigation improvements would be minor and short term.

Converting from flood irrigation to sprinkler irrigation on about 1,100 acres on the refuge would reduce the leaching of nutrients because the amount and distribution of water application can be more easily and precisely controlled. Although this would allow nutrient levels to increase, the reduced period that elk and bison would spend on cultivated fields (due to lower numbers and reduced feeding) would offset gains to some extent because inorganic nitrogen levels and nitrogen mineralization rates due to animal waste would decline. Leaching would continue on up to 500 acres in flood-irrigated fields. Fertilizer use on cultivated fields would further increase nutrients in the soil. It is not clear whether inorganic nitrogen levels and nitrogen mineralization rates would increase or decrease in other habitats (e.g., some sagebrush shrublands, native grasslands, and wet meadows on the refuge and immediately to the east of the refuge). Although there would be fewer elk and bison under Alternatives 4, 5, and 6 than under baseline conditions, there could be greater use of these native habitats under Alternatives 4 and 6 due to reduced feeding, which would mean higher levels of nitrogen. However, if fewer animals used these habitats, then nitrogen levels would decline.

Soil compaction impacts in the short term would be similar to baseline conditions, but in the long term they would decline to a negligible degree due to fewer elk and bison, increased distribution and movements of elk and bison (Alternatives 4 and 6), and reduced use of heavy equipment for winter feeding operations (Alternatives 4 and 6).

In Grand Teton National Park soil conditions in areas grazed by bison would remain similar to baseline conditions in the short term, but with fewer bison, soil compaction, inorganic nitrogen levels, and nitrogen mineralization rates would decline by a negligible degree over the long term. In the short term, restoring native vegetation to 4,500 acres of agricultural lands in the park would result in negligible adverse effects, similar to Alternative 2. In the long term, natural soil conditions would be restored.

Increased winter use of Bridger-Teton National Forest and associated state feedgrounds by elk under Alternatives 4 and 6 could increase soil erosion in localized areas, as described in Alternative 2. Soil erosion would not increase to the extent it could under Alternatives 2 and 3. Soil erosion caused by bison grazing on south and southwest-facing slopes immediately east of the refuge would decline due to substantial reductions in bison numbers under Alternatives 4, 5, and 6.

If large numbers of elk began migrating to other areas under Alternative 6, soil erosion could increase in localized areas, including state feedgrounds. It is not known whether soil erosion caused by bison grazing on south and southwest-facing slopes immediately east of the refuge would increase or decrease; bison numbers would be substantially lower under Alternative 6, and no supplemental forage would be provided for bison in the long term under Alternative 6.

Conclusion

Alternatives 4, 5, and 6 would result in short-term soil disturbance of an estimated 9.4 acres along approximately 61,106 feet of water pipeline right-of-way on the refuge, with minor adverse effects. Additionally, soil in cultivated parts of the refuge would be periodically disturbed during disking and reseeding activities. Soil on agricultural lands in Grand Teton National Park would be temporarily disturbed by efforts to restore native vegetation (similar to Alternatives 2 and 3). Long-term impacts on soils would be beneficial. Potential effects on soils in the park would not cause impairment to park resources.

Mitigation

Short-duration soil disturbances, such as the disturbance during the construction of irrigation pipelines, would be mitigated by screening or using hay bales to reduce the potential of sediments reaching stream channels. Also, to the extent that nutrients were depleted, additional fertilizers would be used to lessen this impact.
CHAPTER 4. ENVIRONMENTAL CONSEQUENCES

WATER RESOURCES

WATER QUANTITY

Potential effects on water quantity on the refuge would primarily result from irrigation practices, including the methods of conveying water from source waters to irrigation systems. Effects on water quantity were evaluated in the 1998 Irrigation System Rehabilitation Plan Environmental Assessment (USFWS 1998), and the following assessment incorporates these findings, as well as supplementary assessments.

Impacts of the Alternatives

Alternatives 1 and 3 (Option A)

Analysis

An estimated 40% of diverted water used for irrigation currently is lost in transport, which would be expected to continue under Alternatives 1 and Option A of Alternative 3. Under Alternative 1 sprinkler irrigation would continue on only 60 acres, or about 5% of the amount of land that is being irrigated.

The actual amount of water that would continue to be diverted from Flat, Nowlin, and Cache creeks for flood irrigation of cultivated fields is unknown, but adjudicated water rights allow for the diversion of up to 105 cfs.

Water diversions for refuge irrigation purposes during peak run-off do not appear to be large enough to adversely impact streams and riparian vegetation. Water diversions from July through September, however, can involve substantial proportions of stream flow, when water levels are normally low and evaporation and transpiration rates are highest. In some cases this causes sections of streams below outtakes to go dry, putting stress on organisms dependent on water flow and wet or moist soils.

Conclusion

A substantial amount of water would be diverted for irrigation during peak run-off in May and June under Alternative 1 and Option A of Alternative 3, with negligible adverse effects because of the remaining large volume of water that would continue to flow in the creeks. However, from July through September diversions could continue to cause some sections of streams below outtakes to go dry, putting stress on organisms dependent on water flow and wet or moist soils.

Water quantity in the park would be unaffected by elk and bison management, and there would be no impairment of water resources.

Alternatives 2 and 3 (Option B)

Analysis

Water would no longer be diverted from Flat Creek, Nowlin Creek, and Cache Creek to meet National Elk Refuge irrigation demands under Alternative 2 and Option B of Alternative 3. Because the amount of water that has been diverted during peak flows in the recent past has not been a large portion of the stream flow, cessation of irrigation would likely increase water flow only to a minor degree. However, because the amount of water that currently is diverted from July through September (after the peak-flow period) comprises a large portion of the stream flow, stopping irrigation would result in a moderate to major increase in stream flows during this period.

No further irrigation on the National Elk Refuge would result in the forfeiture of refuge water rights, which would severely limit any future water projects or irrigation projects. Junior downstream users would have access to the abandoned water. This means that, although water flows on the National Elk Refuge, immediately below the refuge, and below the Cache Creek diversion would increase, increased water flows would not extend very far downstream.

Neither alternative would affect the quantity of water in park waters.

Conclusion

Stopping water diversions for irrigation purposes on the refuge would have minor benefits to stream flow in May and June, but major benefits to parts of streams during July and August, which is a critical period for streams and riparian zones. Water quantity in the park would be unaffected, and no park resources would be impaired.
Alternatives 4, 5, and 6

Analysis

Converting to a sprinkler irrigation system on up to 1,100 acres would increase water-use efficiency under these alternatives from about 5%–10% under Alternative 1 to an estimated 60%–70% (Kremer and Cornia, pers. comm., as cited in USFWS 1998). Less water would be diverted from Flat, Nowlin, and Cache creeks. This would result in only minor increases in stream flow below outtakes during peak-flow periods. Flood irrigation would continue on up to 500 acres, but the delivery system would be improved to reduce loss. However, later in the summer when stream flow has declined still further, it is possible that nearly all or all water in the stream channel would be diverted for irrigation. The difference between these alternatives and Alternative 1 is that more acreage could be irrigated during this period. Except for the end of the irrigation season, when large amounts of water (and possibly all available water) would be diverted for sprinkler irrigation, water saved through more efficient conveyance, distribution, and use would remain in the watercourses.

These alternatives would not affect the quantity of park waters.

Conclusion

While more efficient use of water under Alternatives 4, 5, and 6 could increase stream flows, most or all of the available water during the most critical period (July–August) would continue to be diverted. Benefits to streams and riparian areas would be negligible to minor under these alternatives. None of these alternatives would cause impairment of park water resources.

Mitigation

Major reductions in water flow during July and August could be mitigated under Alternatives 3–6 by reducing the amount of water diverted during this time period. For example, it might be possible to supplement sprinkler irrigation with flood irrigation only during May and June.

WATER QUALITY

Methodology Used to Analyze Impacts

Available information on water quality was reviewed for this analysis. While it is unknown what the precise impacts on water quality would be under any alternative, potential effects were evaluated based on numbers and distribution of elk and bison, the potential for large amounts of fecal material to be produced by concentrations of wintering elk and bison, the type and extent of irrigation and farming practices, and the efficiency of water use. The standard threshold definitions were used.

A beneficial effect would result in improved water quality as compared to baseline conditions, for example, from a decrease in herd size, greater dispersion of herds during winter, and any action that would tend to moderate water temperature either by increasing water use efficiency or increasing the height and canopy cover of streamside vegetation.

An adverse effect would result in the degradation of water quality as compared to baseline conditions, for example, from larger elk and bison herds, greater concentration of herds during winter feeding, and any action that would increase water temperature either by decreasing water use efficiency or reducing the height and canopy cover of streamside vegetation.

Impacts of the Alternatives

Alternative 1

Analysis

Water quality on the refuge is affected by concentrations of large numbers of elk and bison for several months each winter, diversion of water for flood irrigation, disking, and infrequent application of fertilizers.

In the short term this alternative would result in few if any changes in water quality as compared to baseline conditions on either the refuge or in the park. Large concentrations of elk and bison on the refuge in the winter would continue to introduce unnaturally high amounts of fecal material into watercourses, resulting in elevated fecal coliforms and nutrients. Existing farming practices
would continue to result in short-term, negligible to minor, adverse effects to water quality due to erosion when disking, with the potential to persist until ground cover was reestablished. Infrequent application of fertilizers can contribute to nutrient enrichment of watercourses, depending on a wide variety of factors such as weather, ambient soil conditions, and the type of fertilizer, which could result in minor to moderate adverse effects on water quality.

Over the long term a large increase in bison numbers could result in minor adverse effects on water quality on the National Elk Refuge as a result of more fecal material entering surface runoff. Also over the long term, the minor reduction in woody riparian vegetation in the southern part of the refuge could result in negligible to minor increases in water temperature in some streams. The areas affected are small, and most woody riparian vegetation has already disappeared.

Large animal concentrations and farming practices would contribute to negative long-term effects on downstream water quality due to conveyance of fecal material, sediments, nutrients, and fertilizers into surface waters.

**Conclusion**

Under Alternative 1 impacts to water quality would likely continue, primarily as a consequence of large concentrations of elk and bison on the refuge, continued diversion of water for flood irrigation, and continued disking in cultivated areas. Growing bison numbers would intensify adverse impacts over the long term. Water quality (specifically temperature and fecal coliforms) could be subject to long-term, minor, adverse effects. This alternative would likely result in the lowest water quality of any of the alternatives. No park water resources would be impaired.

**Alternative 2**

**Analysis**

In the short term this alternative would result in negligible changes in water quality. As elk and bison numbers declined, winter feeding and irrigation would be phased out, and approximately 2,400 acres of cultivated fields would be restored to natural conditions, and harrowing and fertilizing would be discontinued. As a result, this alternative would likely have long-term, major beneficial effects to water quality on the National Elk Refuge. Maximum elk numbers could decrease by an estimated 20% as compared to baseline conditions (from about 7,500 down to an estimated 6,000 elk), and the range in numbers would decline from approximately 5,000–7,500 to an estimated 1,200–6,000 elk. Bison numbers could decline by as much as an estimated 50%–75% compared to baseline conditions (from an estimated 1,000 down to 250–500 bison). Because winter feeding would be phased out and elk and bison numbers would be reduced, animals would no longer congregate in large numbers, which could reduce the amount of fecal coliforms and nutrients introduced into water courses. The limited amount of riparian woody vegetation that would likely recover under Alternative 2 would have no more than negligible effects on water temperature. Improvements in water quality would likely be higher under this alternative than Alternative 1, in part because of reduced concentrations of bison and elk by the end of the 15-year plan.

Water quality in Grand Teton National Park would be subject to short-term, negligible to minor, adverse effects due to soil disturbance from restoring 4,500 acres of agricultural lands, which could increase sedimentation until native vegetation took hold. In the long term a healthier vegetation community on agricultural lands would possibly enhance water quality by a negligible degree. Reduced forage availability on the refuge during winter could cause a greater increase in elk utilization of riparian areas in the park. If browsing pressure increased to the extent that plant community structure was altered substantially, water quality could be lowered to a negligible degree in areas that are browsed.

**Conclusion**

Alternative 2 would likely result in lower levels of fecal coliforms, sediments, nutrients, and fertilizers into downstream waters, as compared to Alternative 1, resulting in the greatest long-term beneficial impacts to water quality on the refuge and in the park. Reductions in elk and bison numbers; increased distribution and movements of animals; eventual elimination of irrigation, farm-
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ing, and fertilizer use; and conversion of agricultural lands to native vegetation would likely have beneficial effects on water quality. Short-term, negligible to minor, adverse impacts to water quality in the park could result from restoring 4,500 acres of agricultural lands to native vegetation. This alternative would not result in the impairment of park water resources.

Alternative 3

Analysis

On the National Elk Refuge short-term effects of this alternative on water quality would be negligible. Over the long term, however, this alternative could result in a moderate improvement in water quality on the refuge if farming was continued (Option A). Any improvement under this alternative would result primarily from an estimated 70%–80% decrease in the numbers of wintering elk combined with a major reduction in years when supplemental food was provided. Bison numbers would not be permitted to grow as they would under Alternative 1. Lower concentrations of elk and bison would likely result in fewer fecal coliforms and nutrients being introduced into water sources. As a result, riparian woody vegetation along some streamcourses would be able to increase, which would likely moderate water temperatures. Option B of Alternative 3 would result in additional beneficial effects to water quality due to less sedimentation and fertilizers as farming practices were phased out.

In Grand Teton National Park water quality would be subject to short-term, negligible to minor, adverse effects from potential sedimentation as a result of restoring 4,500 acres of agricultural lands, similar to Alternative 2. As compared to Alternative 2, far fewer elk in the Grand Teton National Park herd segment and fewer elk on the National Elk Refuge could reduce the potential for increased browsing of woody vegetation in park riparian areas. However, large numbers of elk from southern Yellowstone and the Teton Wilderness would continue to migrate through Grand Teton, and an increasing number could begin wintering in the park due to major reductions in winter feeding on the refuge. Because bison numbers would not decline as compared to baseline conditions, water quality concerns would continue in Grand Teton National Park in localized areas.

Alternative 3 would likely result in lower levels of fecal coliforms, sediments, nutrients, and fertilizers into downstream waters, as compared to Alternative 1, but reductions would not be as great as they would be under Alternative 2.

Conclusion

Both Options A and B of Alternative 3 would likely result in long-term, beneficial effects to water quality on the National Elk Refuge, although not to the same extent as under Alternative 2. Despite many similarities with Alternative 2, bison numbers would remain high (both options) and flood irrigation and farming would continue (Option A), which could limit improvements in water quality.

In Grand Teton National Park temporary, adverse effects from restoring native vegetation on most agricultural lands would be negligible to minor. Water quality might be improved somewhat compared to Alternative 1 because of fewer elk and bison and the restoration of most agricultural lands. This alternative would not result in the impairment of park water resources.

Alternatives 4, 5, and 6

Analysis

Water quality on the refuge under Alternatives 4, 5, and 6 would be subject to short-term, minor, adverse effects from soil erosion (resulting in increased sedimentation) due to construction activities for irrigation pipeline installation. Over the long term, water quality on the refuge would likely improve by a moderate amount due to a decline in elk numbers (an estimated 20%–33% decline under Alternative 4, and 50%–75% under Alternative 6) and bison numbers (an estimated 50% decline under Alternatives 4 and 6, and 60%–65% under Alternative 5). Reducing supplemental feeding under Alternative 4 and phasing it out under Alternative 6 would likely result in wider winter distribution of animals and less potential for contamination of water sources from fecal coliforms and nutrients. Even though bison numbers would be lower under Alternative 5, elk numbers would remain high, and feeding would continue
nearly every year, with large amounts of fecal material near feedgrounds potentially entering watercourses.

Under all alternatives replacing flood irrigation with sprinkler irrigation would result in more water remaining within watercourses, contributing to improved water quality. Restoring willow and cottonwood habitats along lower Flat Creek would help these communities recover, increasing shading of the stream and possibly reducing water temperature. Reducing available grazing acreage in the southern part of the refuge by 600 acres under Alternative 4 would offset some of the benefits of lowering elk numbers in this alternative by further concentrating elk and impacting riparian vegetation.

Potential effects of restoring native vegetation on previously cultivated fields in Grand Teton National Park would have a short-term, negligible to minor, adverse effect and a long-term, negligible, beneficial effect on water quality, similar to Alternative 2.

**Conclusion**

Alternatives 4, 5, and 6 would likely result in lower levels of fecal coliforms, sediments, nutrients, and fertilizers in downstream waters, as compared to Alternative 1 because of fewer animal numbers and a sprinkler irrigation system. The reduction would be greatest under Alternative 6 (comparable to Alternative 2) because of the phaseout of supplemental feeding and least under Alternative 5 because of more elk and continued supplemental feeding.

Water quality in the park could potentially improve over the long term due to fewer elk and bison and the restoration of 4,500 acres of agricultural lands to native vegetation communities, although restoration activities would result in short-term, negligible to minor, adverse impacts. This alternative would not result in the impairment of park water resources.

**MONITORING**

Water quality parameters would continue to be monitored at least every five years, regardless of alternative selected, for nitrogen and other nutrients, sediment, and fecal coliforms. Consideration would be given to monitoring water temperature and extent of shading by riparian vegetation.

**MITIGATION**

Management actions under each alternative would be conducted so as to avoid the degradation of water quality to the maximum extent practicable. Measures would be employed to prevent or control spills of fuels, lubricants, and other contaminants from entering watercourses and wetlands. Actions must be consistent with state water quality standards, to the extent possible, and with Clean Water Act section 401 certification requirements.

Erosion and siltation control measures would be undertaken during pipeline construction on the refuge for Alternatives 4, 5, and 6 and during activities associated with restoring native vegetation to agricultural lands in the park for Alternatives 2–6. All exposed soil would be stabilized at the earliest practicable date.

**VISUAL RESOURCES**

Visual resources could be affected by several actions being considered for the refuge, including conversion to sprinkler irrigation systems, use of large equipment (e.g., to distribute alfalfa pellets), maintenance of large structures (e.g., the Quonset huts for storing alfalfa pellets), construction of fenced exclosures, and prescribed fire, as well as changes in vegetation and the numbers and distribution of elk, bison, and other wildlife.

Visual resources in Grand Teton National Park could be affected by the active restoration of previously cultivated areas and by the numbers and distribution of elk and bison.

The potential effects of changes in the sprinkler irrigation system on the refuge were analyzed in the *Irrigation Systems Rehabilitation Plan Environmental Assessment* (USFWS 1998). The analysis of potential effects resulting from changes in other management actions and from changes in elk and bison numbers was done qualitatively.
Impacts on the Physical Environment: Visual Resources

Methodology Used to Analyze Impacts

The evaluation of potential effects of changes in irrigation practices on visual resources focused on the “visual absorption capabilities of Refuge lands in relation to the most visually intrusive irrigation scenario being considered” (USFWS 1998). The scenario that was evaluated in detail was analyzed from five different angles and distances and is similar to the irrigation system included in Alternatives 4, 5, and 6, except that the center pivots in the Ben Goe project area were changed to side-roll sprinklers in Alternatives 4 and 5, and two center pivot sprinklers in the Peterson project area are included in Alternatives 4, 5, and 6. The following impact analysis addresses these changes.

Locations selected for detailed analysis represent areas of high visual sensitivity and differing landscape classes, a range of close and distant views of sprinkler irrigation equipment, and views of both single and multiple equipment scenarios likely to be seen by large numbers of visitors. The likelihood of seeing more than one irrigation system at one time was considered in an attempt to more comprehensively measure actual visual impacts of converting from flood irrigation to sprinkler irrigation. Viewpoint locations included the Headquarters, Nowlin, and Ben Goe project areas.

Impacts of the Alternatives

Alternative 1

Analysis

Management activities and facilities associated with elk and bison management on the National Elk Refuge and in Grand Teton National Park would continue to affect visual resources to the extent they have in the recent past.

National Elk Refuge — The flood irrigation structures and facilities that would be maintained under this alternative would continue to adversely affect the visual quality of the National Elk Refuge to a minor degree for some people visiting the refuge. For other people, this would not affect visual quality. Flood irrigation structures are low to the ground and are minimally intrusive.

More prominent, but more localized, are the side-roll sprinklers in the Headquarters area and the Quonset hut at the Nowlin area. The effects of these structures on visual quality are minor due to their localized nature and, more importantly, because they are in the vicinity of other human-made structures. Facilities are close to the road and are within 0.5 mile of town. The Nowlin Quonset hut is near storage sheds and several cabins.

During winter large diesel trucks with trailers would continue to be seen distributing alfalfa pellets each morning in the Headquarters, Nowlin, and Poverty Flats feeding areas (the McBride feeding area is not viewable). This would occur for an average of about 70 days each winter during about 9 out of 10 winters. Prescribed fire would continue on fewer than 5 days per year and effects would be temporary.

In the late fall and early winter, prior to winter feeding, visitors traveling along U.S. 26/89 would see large numbers of elk on many days from pullouts along the highway and from some locations along the Elk Refuge Road, but only small numbers on other days. Once feeding operations begin, elk would continue to be tightly concentrated along feedlines or adjacent to feedlines for a few hours in the morning. Later in the day they would be more scattered, but still readily viewable. Bison viewing opportunities on the refuge during the winter season would continue to be low in the foreseeable future because they are fed primarily at the McBride feedground, which is not viewable from open roads or the highway. A few bison have been finding their way to the Poverty Flats feedground, which is also far from public viewing locations. As the bison population expanded, more bison might be seen nearer the highway and open

Storage shed and Quonset hut used for alfalfa pellets.
refuge roads. Small, localized areas denuded of vegetation by bison wallowing or overgrazing might detract from the aesthetics of the refuge environment from some perspectives.

Vegetation along Flat Creek would remain dominated by wet meadow and marsh communities. Over the long term, the cottonwood stand along upper Flat Creek would be lost and aspen stands would continue to be lost in the Gros Ventre Hills. Eventually, all aspen stands could be lost in the Gros Ventre Hills, which can now be seen from the Kelly Road in Grand Teton National Park. The cottonwood stands on upper Flat Creek can be seen from Flat Creek Road on the National Elk Refuge during the months it is open to the public.

The introduction and spread of bovine tuberculosis, bovine paratuberculosis, chronic wasting disease, or other non-endemic, infectious diseases could impact the scenery of the refuge to the extent that elk and/or bison populations were reduced. Very limited information has not revealed paratuberculosis in the Jackson bison herd. Elk and bison are important parts of the scenery of Jackson Hole at all seasons. If populations were substantially reduced, impacts to visual resources could be moderate to major under this alternative.

Grand Teton National Park — The large number of elk and bison in Grand Teton National Park during spring, summer, and fall would continue to add positively to the park’s visual resources. Because bison are typically much more visible than elk in the park, they are an important component of the visitor experience. While a large bison herd over time would increase viewing opportunities, more bison could also result in localized damage to plant communities, which could detract slightly from the natural scenery of the area.

As described under the National Elk Refuge, an outbreak of a non-endemic infectious disease could have major impacts on visual resources and wildlife viewing opportunities.

Nonnative vegetation (smooth brome, musk thistle, and other invasive species) on approximately 4,500 acres of agricultural lands in Grand Teton National Park would continue to be unappealing to some people. Also, the sight of hunters dressed in blaze orange along U.S. 26/89 and other roadways in the park during the fall and early winter could continue to detract from the scenic quality for some visitors.

Other Federal Lands — Elk wintering on the National Elk Refuge and summering in Yellowstone National Park, the Teton Wilderness, and the Gros Ventre River drainage would continue to contribute to visual resources in these areas.

Conclusion

The overall scenic quality of the refuge and park would remain much the same as it is today, except that bison would be much more abundant and viewable during the summer. The decline and eventual disappearance of aspen habitat on the National Elk Refuge would contribute to the loss of aspen habitat in Jackson Hole. The disappearance of remaining willow stands in the southern part of the National Elk Refuge and the cottonwood stands along upper Flat Creek would likely be noticed by few people. This alternative would not impair any visual resources in the park.

Alternative 2

Analysis

National Elk Refuge — As compared to Alternative 1, elk and bison management on the National Elk Refuge under Alternative 2 would gradually result in a more natural landscape.

Changes would include the restoration of native vegetation in cultivated fields and the removal of flood-irrigation structures and facilities, side-roll sprinklers, and the Quonset storage huts. It is possible that the elk and bison fence along the southern boundary of the National Elk Refuge and along U.S. 26/89 would also be removed. Diesel trucks would no longer be driven in four feeding areas every morning an average of 70 days each winter.

Reduced smoke from eliminating the prescribed fire program on the National Elk Refuge would have a negligible beneficial impact on visual resources.

As compared to Alternative 1, fewer elk and bison wintering on the National Elk Refuge would present more natural viewing opportunities. Instead of being artificially concentrated along feedlines,
elk and bison would be more widely distributed as they search for forage, and visitors would see fewer animals than under Alternative 1.

If large numbers of elk and bison continued to overwinter on and near the National Elk Refuge, there would be little, if any, improvement to willow, cottonwood, and aspen stands, and some stands could continue to decline and might ultimately disappear. This would result in visual resources being affected similarly to Alternative 1. If, however, elk began migrating to other wintering areas, and fewer elk remained on the refuge, willow, cottonwood, and aspen stands would begin recovering, which would contribute to a more natural looking landscape.

Adverse impacts to visual resources due to reductions in elk and bison numbers caused by a potential outbreak of an infectious disease would be lessened under this alternative, as compared to Alternative 1, because fewer animals would be present, and the prevalence rate would likely be lower than under any other alternative (except Alternative 3). Therefore, numbers would likely not decline as much as they would under the other alternatives (except Alternative 3).

Grand Teton National Park — Large numbers of bison would continue to be seen in Grand Teton National Park during summer and other seasons, although there would be fewer bison than under Alternative 1. Fewer elk, and more naturally fluctuating populations, could reduce wildlife viewing opportunities by a negligible or minor degree for some people. As described for the National Elk Refuge, visual resources could be affected by an outbreak of a non-endemic infectious disease, but adverse impacts under this alternative would be more similar to what would happen in a natural situation.

Restoring approximately 4,500 acres of agricultural lands in Grand Teton National Park would result in a more natural looking and more appealing landscape for some people, although many people would not notice the difference. The process of disking and reseeding former fields would temporarily adversely affect the natural appearance of these lands for a short period. Eliminating the elk reduction program in Grand Teton National Park would enhance the naturalness of the scenery during the fall and early winters because hunters dressed in blaze orange would no longer be seen in the park.

Other Federal and Private Lands — Potentially minor reductions in the number of elk in Yellowstone National Park, the Teton Wilderness, and the Gros Ventre River drainage could result in negligible reductions in visual resources in these areas. If large numbers of elk began migrating to the Green River basin and the Red Desert, in addition to migrating pronghorn and mule deer, wildlife viewing opportunities would be enhanced for people along the migration route.

**Conclusion**

Alternative 2 would contribute to a more natural looking landscape in the southern Jackson Hole area. If elk and bison did not begin using other winter ranges, overbrowsing of aspen and other woody plant communities could contribute to a further decline. Views of elk and bison on the refuge would be more natural because animals would not be artificially concentrated along feedlines, but fewer numbers of elk and bison than under Alternative 1 would diminish visual resources and the visual quality of the refuge and the park for some people. This alternative would not impair any visual resources in the park.

**Alternative 3**

**Analysis**

National Elk Refuge — As compared to Alternative 1, elk and bison management on the National Elk Refuge would result in a transition to a more natural landscape on the National Elk Refuge, but not to the extent of Alternative 2.

Under Option A of Alternative 3, the scenery associated with cultivated portions of the National Elk Refuge would remain the same as Alternative 1, except side-roll sprinklers in the Headquarters project area would be removed. This would be a negligible change because facilities would remain in the area.

Under Option B cultivated fields would be restored to native vegetation. Impacts would be similar to Alternative 2 as a result of removing flood-irrigation structures and facilities, as well as side-roll sprinklers. However, because winter
feeding would continue under this alternative in the more severe winters, the Quonset huts would remain and diesel trucks would continue to be driven to the four feeding areas each morning, although not as frequently as under Alternative 1.

Prescribed fire would continue on only a few days each year, similar to Alternative 1, and effects on scenic quality would be temporary and negligible.

As compared to Alternative 1, views of elk and bison wintering on the National Elk Refuge would be somewhat more natural because fewer animals would be present, and they would be more widely distributed as they searched for forage. Under Alternative 3 bison would not be a regular part of the scenery, similar to Alternative 2.

If large numbers of elk migrated to the Green River basin and the Red Desert, aspen and willow habitat could recover on the refuge due to fewer elk browsing on woody vegetation. This would add to the naturalness of the scenery on the refuge.

A potential outbreak of a non-endemic infectious disease would have fewer effects on visual resources under this alternative than Alternative 1 because reducing winter feeding and eliminating irrigation (Option B) would reduce animal concentrations, similar to Alternative 2. Although animal numbers would decline if an infectious disease became established, the prevalence rate would likely be lower than under Alternative 1, and numbers would likely not decline to the same degree.

Grand Teton National Park — Large numbers of bison would continue to be seen in Grand Teton National Park during summer and other seasons, similar to baseline conditions, although there would be far fewer elk than under Alternative 1. As described for the refuge, impacts on wildlife viewing opportunities from a non-endemic infectious disease would be substantially lower than under Alternative 1 (and would be similar to Alternative 2) because the prevalence rate would likely be lower.

Similar to Alternative 2, restoring approximately 4,500 acres of agricultural lands to native vegetation would result in a more natural looking and more appealing landscape to some people, although many people would not notice the difference. The process of disking and reseeding former fields would temporarily adversely affect the natural appearance of these lands. The likely recovery of aspen stands that otherwise would have been lost under Alternative 1 due to browsing by elk, in combination with fire suppression, would enhance the scenic quality of the park to a negligible degree.

The presence of elk hunters in Grand Teton National Park would detract from the naturalness of the scenery for some visitors during the fall and early winter.

Other Federal Lands — Potentially minor reductions in the number of elk in Yellowstone National Park, the Teton Wilderness, and the Gros Ventre River drainage and potential minor increases during some years would result in a greater variability of wildlife viewing opportunities in these areas. However, the effect on visual quality would be negligible in most years. If large numbers of elk began migrating to the Green River basin and the Red Desert, opportunities to view elk (in addition to pronghorn and mule deer) would be enhanced for some people.

Conclusion

Alternative 3 would contribute to a slightly more natural looking landscape in the southern Jackson Hole area, including aspen stands and willow habitat. Views of elk and bison on the refuge would be more natural due to a major reduction in the artificial concentration of animals along feedlines. Relatively small numbers of elk compared to Alternative 1 would diminish visual quality on the refuge and in the park for some people, but maintaining large numbers of bison and increased visibility of bison on the refuge would offset these impacts to some extent. This alternative would not result in the impairment of visual resources in the park.

Alternatives 4 and 5

Analysis

National Elk Refuge — The center pivot sprinkler systems that would be constructed under these alternatives would be either hidden from view (e.g., those in the McBride project area) or
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The visual impact of side-roll sprinkler irrigation on the refuge would be negligible to minor. It would be difficult to visually distinguish because of their distance from roads and highways and because they would blend into the background (those in the Nowlin and Peterson project areas). The three center pivots in the Nowlin project area would blend into the strong visual backdrop of Miller Butte when viewed from the highway turnout near the fish hatchery. The two center pivots in the Peterson project area would be easier to see from most locations along the highway, but given the distance would not be noticeable to many viewers traveling at highway speeds (i.e., 40–60 mph) along this view corridor. Also, the metal-roofed Quonset huts and cabins in the middleground include a human agricultural element in the view plane and make the irrigation equipment compatible within this context. Irrigation equipment would be less conspicuous during late summer and fall when taller, honey-colored grasses are present than in the spring and early summer. The addition of center pivots in the Nowlin and Peterson project areas would be visually obtrusive to some visitors.

Constructing one small pumphouse (12 feet square) in the Nowlin area would have minor visual impacts. The pumphouse would be similar in size, shape, color, and construction materials to the town’s pumphouses in the Headquarters area. It would also be located near several existing buildings found in the Nowlin area.

The visual impacts of side-roll and hand-line sprinklers in the Ben Goe and Headquarters areas would be negligible to minor. The sprinklers would cover more area but would be much lower and not as noticeable. Even though the irrigated fields in the Headquarters area extend all the way to the southern refuge boundary adjacent to Jackson, the sprinklers would be indistinguishable from more than 0.5 mile. Side-roll sprinklers adjacent to Elk Refuge Road would be within about 50 feet of the road edge and about 10 feet below the road grade. This view is seen by all road users leaving the interior of the National Elk Refuge. The Headquarters area receives the heaviest year-round use of any other interior area. Views of side-roll line wheels would be more noticeable closer to the roadway. Well buildings and residences in the middleground introduce a human element into the view plane and make the irrigation equipment compatible within this context. These irrigation structures, at least the southern portions and systems to the west, would be almost indistinguishable to the naked eye.

Views of elk and bison wintering on the National Elk Refuge under Alternative 5 would be similar to Alternative 1. Views over the long term under Alternative 4 would be similar to Alternative 1 in winters with continued feeding operations, but in non-feeding years views would be somewhat more natural due to fewer elk and wider distribution of animals as they search for forage. Numbers of elk viewable during most days in half of the winters would be much lower than under Alternative 1; bison are not readily visible from U.S. 26/89 or most points along Elk Refuge Road. Under Alternative 4 large numbers of elk and bison could be seen grazing on the southern part of the refuge on some days.

Willows along Flat Creek would recover inside a fenced exclosure that would be readily visible.
from the highway under both Alternatives 4 and 5. Because willows would recover only inside the exclosure, the scenic quality of the National Elk Refuge would not necessarily be enhanced. The edges of the willow stand would have squared corners and sharp edges, rather than blending into the natural environment. Adaptive changes to exclosures in the long term under Alternative 4 could reduce visual impacts. The aspen exclosure would result in few visual impacts because the irregular fence-line and the fence would not be visible from the Kelly Road.

Adverse impacts to visual resources caused by a potential outbreak of an infectious disease would be somewhat less under Alternative 4, as compared to Alternative 1, but likely higher than under Alternatives 2, 3, and 6, because moderately reducing winter feeding would help reduce unnaturally high concentrations of these animals. Risks under Alternative 5 would be similar to Alternative 1.

Grand Teton National Park — The number of bison under Alternatives 4 and 5 (350 to approximately 500) would be similar to the numbers that existed from 1996 to 1999, but retaining relatively high numbers of elk would continue to contribute to wildlife viewing opportunities in Grand Teton National Park during spring, summer, and fall. As described for the National Elk Refuge, a non-endemic infectious disease could have a major, adverse impact on visual resources.

Restoring approximately 4,500 acres of agricultural lands in Grand Teton National Park to native vegetation under Alternatives 4 and 5 would reestablish a more natural looking and more appealing landscape for some people, although many people would not notice the difference. The process of disking and reseeding former fields would adversely affect the natural appearance of a small part of the park for a short period.

Continued elk herd reduction in parts of Grand Teton National Park would detract from the naturalness of the scenery for some visitors during the fall and early winter.

Other Federal Lands — The number of elk summering in Yellowstone National Park, the Teton Wilderness, and the Gros Ventre River drainage could increase by a negligible to minor amount under Alternatives 4 and 5. This could improve visual resources in these areas by a negligible degree.

**Conclusion**

Converting to sprinkler irrigation under Alternatives 4 and 5 would contribute to a slightly less natural looking landscape on the National Elk Refuge near the town of Jackson, as compared to Alternative 1. However, within the context of current agricultural activities and structures on the refuge and the highly variable landscape, sprinkler irrigation systems would result in negligible adverse impacts on the foreground character and background views. Restoring willow and aspen habitat on the refuge would enhance the natural look of the refuge. Moderate to large numbers of elk and bison on the refuge and in the park would continue to be important elements of the scenery of Jackson Hole. These alternatives would not result in the impairment of visual resources in the park.

**Alternative 6**

**Analysis**

National Elk Refuge — Approximately 1,100 acres of flood-irrigated fields would be converted to sprinkler irrigation, with impacts similar to those described for Alternatives 4 and 5. Impacts on scenic quality would be negligible to minor.

Actions under Alternative 6 that would enhance visual quality include the removal of the Quonset huts where alfalfa pellets are now stored and the elimination of diesel trucks used for feeding operations, which would be expected to occur in five years. Resulting impacts on scenic quality would be minor, beneficial, and long term.

As compared to Alternative 1, views of wintering elk and bison on the National Elk Refuge would be much more natural due to smaller numbers of elk and bison on most days and to wider distribution of animals as they search for forage. This would be similar to Alternative 2, except there would be fewer elk and bison in some years under Alternative 6. On some days, the National Elk Refuge’s scenery would include large numbers of elk and bison grazing on the southern part of the
refuge, but on other days, elk and bison could be absent, or only a few would be readily visible.

Maintaining elk at objective levels under this alternative would allow most of the willow habitat along Flat Creek on the refuge to recover, which could enhance the viewing experience for some people. This impact would be greater than under Alternatives 4 and 5, where willow habitat would recover inside exclosures, which would be obvious to people passing by on the highway.

Sustaining aspen habitat in temporary and rotating exclosures under Alternative 6 would result in fewer visual impacts than under Alternatives 1, 2, and 3. Because the fenceline would be irregular and would not be visible from the Kelly Road, scenic quality would not be compromised.

Adverse impacts to wildlife viewing due to reductions in elk and bison numbers caused by a potential outbreak of an infectious disease could eventually be lessened under this alternative, as compared to Alternative 1, because winter feeding would be eliminated and unnaturally high concentrations of animals would end. The prevalence rate would likely be lower than under any other alternative (except possibly Alternatives 2 and 3), and numbers would likely not decline to the point they would under Alternative 1.

**Grand Teton National Park** — Although reducing the bison herd to about 500 animals could affect some viewing opportunities, it should not detract noticeably from the park’s visual resources because bison numbers would be similar to what they were in 1996–97. Fewer calves would be viewable, but most visitors would likely not notice the difference. Reducing the elk herd in the park to 1,200–1,600 animals could affect visual resources in the park by a minor to moderate degree for some people. However, elk and bison numbers under this alternative could very well be within the natural range of variability for the area, and bison and elk would continue to be part of the park’s scenery. The continued presence of elk summering in Yellowstone National Park, the Teton Wilderness, and the Gros Ventre River drainage could offset changes in the Grand Teton segment because elk from these areas would still pass through Grand Teton National Park during spring and fall. Furthermore, closing the Blacktail Butte / Kelly hayfields area to elk herd reduction (if that option was chosen) would in the long term slow the movement of elk through the area and offset negative effects of lower elk numbers to some extent; elk viewing opportunities in these areas would likely increase. As described for the National Elk Refuge, a non-endemic infectious disease could affect wildlife viewing opportunities in the park, but under Alternative 6 the impacts would likely be less than under Alternative 1,

Restoring approximately 4,500 acres of agricultural lands in the park to native vegetation would have the same impacts as Alternatives 2–5.

Continued elk herd reduction in the park would detract from the naturalness of the scenery for some visitors. However, it is possible that the herd reduction program could be discontinued if it was no longer necessary to help control elk numbers.

**Other Federal Lands** — If fewer elk summered in Yellowstone National Park, the Teton Wilderness, and the Gros Ventre River drainage, visual resources could increase by a negligible to minor degree, similar to Alternatives 4 and 5. If elk began migrating out of the Jackson Hole area, people might be able to view large numbers of elk during the migration, enhancing visual resources for them.

**Conclusion**

Alternative 6, similar to Alternatives 4 and 5, would contribute to a slightly less natural looking landscape near the town of Jackson due to sprinkler irrigation of cultivated fields. Overall, impacts on the foreground character and background views would be negligible. Restoring willow and aspen habitat on the refuge would enhance natural conditions. Views of elk and bison on the refuge would be more natural because animals would not be artificially concentrated along feedlines, but numbers of elk and bison would be lower than under Alternative 1, diminishing the visual quality of the refuge and park for some people. This alternative would not impair any visual resources in the park.

**Mitigation**

Setting sprinkler systems back at least 50 feet from road edges would maximize the distance be-
between equipment and viewers and minimize visual intrusion without a major loss of irrigated acreage. Using side-roll systems with small wheel diameters in highly visible areas could reduce their visual impacts. Center pivot sprinklers in some places could be replaced with lower stature sprinkler systems (e.g., side-roll sprinklers). When not being used, irrigation equipment could be aligned parallel to the primary view angle and farthest from the primary viewer location at each site. Dulling the surface or color-coating irrigation equipment would help minimize reflective metal surfaces so the structures would better blend with their surroundings. Any equipment storage facilities would be as far as possible from roads or adjacent to existing facilities. Storage facilities and pumphouses would be constructed with materials and paint hues that would help them blend with their surroundings.

Constructing exclosures (Alternatives 4, 5, and 6) in an irregular shape and with rounded corners would mitigate, to some extent, the unnatural appearance of the willow, aspen, and cottonwood stands that recover inside of the exclosures.

**CUMULATIVE EFFECTS**

Cumulative effects on soils, water quantity, and water quality are not anticipated to occur as a result of impacts of the alternatives in combination with impacts of reasonably foreseeable actions. Negative negligible cumulative effects on visual resources could result under Alternatives 4, 5, and 6 as water irrigation systems on the refuge, combined with more development on private lands and prescribed fire areas in the park and the national forest, resulted in a slightly less natural and scenic landscape.
IMPACTS ON HABITAT

OVERVIEW

The discussion in this section parallels the “Habitat” section in Chapter 3 in that it is subdivided by jurisdictions and landownership: National Elk Refuge, Grand Teton National Park / John D. Rockefeller, Jr., Memorial Parkway, Bridger-Teton National Forest, Yellowstone National Park, other federal and state lands, and private lands. Under each area the plant community types are organized in the same order as in Chapter 3, and each alternative is discussed under each plant community type. Table 4-1 shows the potential changes in the amount of each plant community type across all alternatives.

The analysis of the impacts on refuge habitats assumes that most elk and bison would continue to migrate between the refuge, the national park, and the national forest, only foraging on the refuge from approximately November to April.

In the long term under Alternative 4, the Preferred Alternative, monitoring of habitat improvement may indicate that adaptive management changes to planned exclosures could occur. Large, permanent exclosures could be made smaller, temporary, and rotating. If these changes were made, habitat impacts due to exclosures under Alternative 4 would be similar to those under Alternative 6. Because these potential changes cannot be forecast, habitat impacts are described for Alternative 4 planned actions.

METHODOLOGY USED TO ANALYZE HABITAT EFFECTS

Sources of information used to assess the level of impact on habitat included (1) scientific literature on the effects of management activities and ungulates on plant communities; (2) site-specific information related to habitat conditions on refuge, park, and national forest lands, including current and ongoing studies (when available); and (3) the professional judgment of refuge, park, state, and forest biologists and ecologists familiar with habitat conditions.

Where possible the effects of each alternative on habitat types were quantified. Condition classification systems for willow, aspen, and cottonwood communities were developed from Singer and Zeigenfuss (2003), Dobkin (1994), and Dobkin, Singer, and Platts (2002) (see Table 4-2). These sources were also used to estimate the effects of ungulate browsing activity on woody plant communities along with information provided by E. K. Cole (pers. comm. 2002). Supporting analysis used by Cole to estimate habitat effects of each alternative is summarized in Smith, Cole, and Dobkin (2004).

<table>
<thead>
<tr>
<th>TABLE 4-1: NATIONAL ELK REFUGE — POTENTIAL CHANGES IN HABITAT ACREAGE FROM THE SHORT TERM TO THE LONG TERM UNDER EACH ALTERNATIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline</strong></td>
</tr>
<tr>
<td>Marshlands</td>
</tr>
<tr>
<td>Wet Meadows</td>
</tr>
<tr>
<td>Native Grasslands</td>
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<tr>
<td>Sagebrush Shrublands</td>
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<tr>
<td>Aspen Habitat</td>
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<tr>
<td>Willow Habitat (Classes I/II/III)</td>
</tr>
<tr>
<td>Cottonwood Habitat</td>
</tr>
<tr>
<td>Conifer Forest</td>
</tr>
</tbody>
</table>

**Note:** All acreage totals have been rounded to the nearest 10 acres; therefore, numbers of acres may be slightly different than numbers cited in Chapter 3. An arrow (→) denotes a change in acreage at the end of the short term to the long term. No arrow indicates there would be no change in acreage from the short term to the long term.

* Under Alternative 4 implementation of adaptive management measures could result in different acreages of aspen, willow, or cottonwood habitat.
CHAPTER 4. ENVIRONMENTAL CONSEQUENCES

NATIONAL ELK REFUGE

Marshlands

Impacts of Alternatives 1–6

Analysis

Residual vegetation could be reduced in marshland areas if growing numbers of bison learned to forage in this habitat; currently, bison do not use marshland communities (Cole, pers. comm. 2002). Marshland communities on the National Elk Refuge are expected to experience a negligible change in area or condition in the short and long terms under Alternatives 2 and 3 compared to baseline conditions and Alternative 1 (see Table 4-1).

Under Alternative 2 and Option B of Alternative 3, there would be a potential exception to the negligible change in acres in marshland habitats. An estimated 50 acres (8%) of marshland habitat could be converted to wet meadow habitat in the Headquarters area because Cache Creek would no longer be diverted to irrigate cultivated fields (Cole, pers. comm. 2002). Due to a lack of prescribed fire under Alternative 2, there would also be a reduction in forage production, but the overall condition of marshland habitat would remain good.

Smith, Cole, and Dobkin (2004) assessed habitat changes over the last century on the refuge and noted that “snowpack discharges, stream flows, and irrigation practices have not varied and altered water tables sufficiently to affect riparian and wetland species” (p. 134).

Under Alternatives 4–6, marshland habitat condition and acreage would remain similar to baseline conditions in the long term. In the short term there could be localized, short-duration adverse impacts to marshland habitat due to the installation of water pipes for the sprinkler irrigation system.

Conclusion

The total number of acres of marshland communities on the refuge and the condition of marshland habitat would remain similar to baseline conditions in all alternatives with the possible exception of Alternative 2 and Option B of Alternative 3. Under Alternatives 4, 5, and 6, marshland habitat condition and acreage would remain similar to baseline conditions and Alternative 1 in the long term. In the short term, there could be localized, short-duration adverse impacts to marshland habitat due to the installation of water pipes for the sprinkler irrigation system.

Mitigation

In pipeline construction under Alternatives 4, 5, and 6, it is anticipated that heavy equipment would not need to be used in wetlands, and their use in wetlands would be avoided if at all possible. Prior to construction activities, a survey would be conducted to determine the presence of any wetlands. Any unavoidable impacts to wetlands or “waters of the United States” would be authorized and permitted by the U.S. Army Corps of Engineers prior to implementation of sprinkler irrigation projects. If construction in wetlands was unavoidable, the following measures would be taken. To minimize soil and plant root disturbance and to preserve pre-construction elevations, heavy equipment used in wetlands would be placed on mats. Whenever possible, excavated material would be placed on an upland site; when this was not feasible, temporary stockpiling of excavated material in wetlands would be placed on filter cloth, mats, or other semi-permeable surface, or comparable measures would be taken to ensure that underlying wetland habitat was protected. In such cases, the material would be stabilized with straw bales, filter cloth, or other appropriate means to prevent reentry into the waterway or wetland. Temporary stockpiles in wetlands would be removed as soon as practicable. Wetland areas temporarily disturbed by stockpiling or other activities during construction would be returned to their pre-existing elevations, and soil, hydrology, and native vegetation communities would be restored as soon as practicable.

Wet Meadows

Alternative 1

Analysis

Management actions are not expected to change the water regime under Alternative 1, but an estimated 50 acres of willow habitat would convert to wet meadow habitat in the short term due to continued browsing on willow plants by elk (Cole,
Impacts on Habitat: National Elk Refuge

pers. comm. 2002). This would bring the wet meadow habitat acreage total to an estimated 1,770 acres in the next 15 years (see Table 4-1).

There would be a minor decline in the condition of some wet meadow areas due to bison hoof damage (Cole, pers. comm. 2002). If bison numbers continued to grow over the next 20 years at the existing rate of increase (depending on hunting success in Bridger-Teton National Forest), wet meadow communities would experience moderate negative impacts, declining to a fair to poor condition; this would result in a minor to moderate decrease in forage production. Increased bare areas and erosion would limit the total forage produced and could make areas more susceptible to nonnative plant species such as perennial pepperweed and Canada thistle.

Conclusion

Compared to baseline conditions, wet meadow communities under Alternative 1 would increase by an estimated 50 acres in the short and long terms. Large areas of wet meadow habitat would continue to be heavily grazed each fall and winter, which would sustain a lower amount and height of residual vegetation than under baseline conditions. As bison numbers continued to increase, the amount of heavily grazed wet meadow habitat would increase, and the condition of some wet meadow habitats would decline to fair or poor condition.

Alternatives 2 and 3 (Option B)

Analysis

Under Alternative 2 and Option B of Alternative 3 an estimated 100 acres of wet meadow habitat would likely convert to willow habitat within 15 years due to decreased numbers of elk and bison browsing on remnant willow plants in some wet meadow communities (see Table 4-1). This would be true if the U.S. Forest Service proceeded with habitat improvements in Bridger-Teton National Forest because improved habitat would shortstop elk and bison in the national forest (Cole, pers. comm. 2002). In addition, cessation of winter feeding would not draw elk and bison to the refuge. An estimated 50 acres of marshland habitat could also convert to wet meadow communities due to cessation of irrigation, bringing the total number of acres of wet meadow habitat to an estimated 1,620 acres.

If no habitat improvements occurred in the national forest, elk and bison would continue to browse in wet meadow areas, preventing suppressed willow plants from growing into mature willow stands. There also would be no hunting on the refuge in Alternative 2, but hunting in the national forest would continue, and many elk and bison might stay on the refuge to avoid the hunt, especially if there was no improved winter habitat to keep them in the national forest. In the long term, if many elk and bison continued to use the refuge to escape hunting pressure, the numbers and duration of elk and bison occupation on the refuge would still be too high to result in wet meadow habitat converting to willow habitat (Cole, pers. comm. 2002).

Although there would be fewer elk and bison grazing on wet meadow habitats in the long term, the elimination of winter feeding would sustain a lower amount of residual vegetation, which would be similar to baseline conditions or Alternative 1.

Stopping irrigation diversion from Flat Creek would not likely produce large changes in wet meadow acreage or condition in the short or long terms, but there could be a negligible decline in acreage. The overall condition of wet meadow communities would be expected to remain good. Good condition wet meadow communities would be dominated by near 100% cover of native sedge species and water-tolerant grasses. There would be considerable residual material from the last year’s growth under the bases of growing plants, except in areas that had been previously burned, and few areas would be invaded by nonnative weed species (Cole, pers. comm. 2002).

Conclusion

Wet meadow communities would be fewer by an estimated 150 acres in the long term compared to Alternative 1 (for an estimated average of about 1,620 acres). Although elk and bison numbers would be less than under Alternative 1, large areas of wet meadow habitat would continue to be heavily grazed each fall and winter due to the elimination of winter feeding. Many elk and bison could stay on the refuge rather than in the national forest, where hunting would be allowed;
because of this continued use, most wet meadow habitat on the refuge would not convert to willow habitat.

**Alternative 3 (Option A)**

**Analysis**

Management actions are not expected to change the water regime under Option A of Alternative 3.

An estimated 730 acres of wet meadow habitat would likely convert to willow habitat in 15 years, and an additional 720 acres in the long term due to low elk numbers (Singer and Zeigenfuss 2003). This would decrease the wet meadow acreage from the current estimated 1,720 acres to an estimated 270 acres (see Table 4-1).

In the long term there would be minor physical damage and a decrease in forage production in wet meadows from bison grazing and hoof damage, resulting in increased soil hummocking and erosion (Cole, pers. comm. 2002). The overall condition of wet meadow communities would remain good to fair.

**Conclusion**

Wet meadow habitat would have an estimated 1,500 fewer acres in the long term compared to Alternative 1, due primarily to the conversion of wet meadow habitat to willow habitat, with a long-term estimated average of about 270 acres being sustained. Although elk and bison numbers would be less than under Alternative 1, large areas of wet meadow habitat would continue to be heavily grazed each fall and winter due to significant reductions in winter feeding and the reduced amount of available wet meadow habitat.

**Alternatives 4 and 5**

**Analysis**

Under Alternatives 4 and 5 a 500-acre exclosure would be erected around wet meadow communities with suppressed willow plants to allow the suppressed willows to grow into mature stands by excluding browsing by ungulates. After 15 years an estimated 250 acres of wet meadow habitat would convert to willow habitat inside the 500-acre exclosure (see Table 4-1). In the long term the entire 500 acres in the exclosure would convert to willow habitat. Residual vegetation within the fence would be taller and denser in the short term than under baseline conditions and Alternative 1. In the long term, as willow communities dominated the exclosure, residual herbaceous vegetation would be reduced and would eventually disappear (Cole, pers. comm. 2002). Wet meadow communities outside the exclosure (1,220 acres) would remain in good condition, as described under Alternative 2.

Wet meadow habitats that contain suppressed willows (950 acres) outside the exclosure would remain wet meadow communities because of continued heavy browsing by elk in the short and long terms. Residual vegetation would remain low in many areas.

Few wetlands exist in irrigation project areas. Flat Creek is considered a “water of the United States” by the U. S. Army Corps of Engineers and as such receives protection under the Clean Water Act of 1977. Similarly, a small linear wetland feature along Flat Creek between the Chambers and the southeastern portion of the McBride project areas would be impacted as a result of the proposed pipeline crossing of Flat Creek (Cole, pers. comm. 2002). In addition, several small areas of emergent wetland could occur within proposed locations of sprinkler irrigation systems in the Ben Goe and Nowlin project areas. These wetland areas could be impacted by the change from flood irrigation to sprinkler irrigation. Less surface water would be available with sprinkler irrigation, potentially causing these wetland areas to shrink. The presence of these wetlands, however, has not been verified by certified wetland experts. Whenever possible, construction in wetlands would not take place, but any unavoidable impacts to wetlands or waters of the United States would have to be authorized and permitted by the U.S. Army Corps of Engineers prior to the implementation of sprinkler irrigation projects.

There would be a minor decline in wet meadow acreage if sprinklers replaced flood irrigation in the Headquarters area. While Cache Creek flows would continue to be diverted, there would be much less wastewater with sprinkler irrigation, and therefore less water to supplement wet meadow habitat.
**Conclusion**

Wet meadow communities under Alternatives 4 and 5 would be fewer by an estimated 550 acres in the long term compared to Alternative 1 due mainly to the recovery of willows in the 500-acre exclosure. Large areas of wet meadow habitat outside the exclosure would continue to be heavily grazed each fall and winter.

Localized, short-duration, adverse impacts could result from the installation of the water pipeline for the sprinkler irrigation system, but no long-term effects would result.

**Alternative 6**

**Analysis**

The effects of Alternative 6 on wetland communities on the refuge would be similar to the effects of Alternative 3 (Option A) (see Table 4-1), but there would be less hoof damage and soil hummocking (Cole, pers. comm. 2002). Residual vegetation would remain low in many areas due to the reduced amount of available wet meadow habitat and the elimination of supplemental feeding. However, the overall condition of wet meadow communities would remain good.

**Conclusion**

The acreage of wet meadow communities would be similar to Alternative 3 (Option A), and the overall condition would be good, with less hoof damage and soil hummocking compared to Alternative 1.

**Mitigation**

The mitigation measures to reduce adverse impacts associated with pipeline construction in wet meadow communities would be the same as described above under “Marshlands.”

**Native Grasslands**

**Alternative 1**

**Analysis**

Native grassland communities would likely increase in the short term by an estimated 300 acres and by about 900 acres in the long term (see Table 4-1) as the cottonwood community along upper Flat Creek and the sagebrush shrubland community in Long Hollow and other areas convert to native grassland habitat due to continued heavy browsing by elk and bison (Cole, pers. comm. 2002).

The future condition of native grassland habitats would depend primarily on the control of cheatgrass, crested wheatgrass, and other invasive species, which would continue to increase under current management practices. As a result, the quality of winter forage on native grassland communities would decline (Cole, pers. comm. 2002).

Native grassland habitat would likely remain in good condition at the baseline numbers of elk and bison on the refuge (an estimated 5,000–7,500 elk [average of about 5,600] and approximately 1,000 bison). Zeigenfuss et al. (2003a) found few instances of reductions in vegetation productivity due to grazing by elk and bison and few negative influences of grazing on plant species diversity. Grazing by elk and bison primarily occurs during the dormant season, which does not have the level of impacts that can occur during the growing season (Holechek, Pieper, and Herbel 1995). Nonetheless, heavy grazing in some areas has resulted in a higher percentage of bare ground and slightly higher cover of exotic plant species (Zeigenfuss et al. 2003a).

Trampling, trailing, and dense manure accumulation would continue near the feedgrounds and could spread to more locations, but relative to the entire native grassland acreage on the refuge, these effects would be minor (Cole, pers. comm. 2002). As bison numbers increased, negative effects would grow, depending on the number of bison and the length of time they spent on the refuge.

Under Alternative 1 most native grassland communities on the alluvial fan would not convert to sagebrush shrubland habitat in the long term because large numbers of browsing elk and bison would prevent sagebrush from reestablishing.

**Conclusion**

It is estimated that native grassland habitats on the refuge would increase by about 300 acres in the short term and by about 900 acres in the long term.
term as cottonwood habitat and sagebrush shrubland converted to native grassland habitat due to excessive elk and bison browsing. Most native grassland communities would probably remain in good condition in most areas of the refuge in the short term, but unlimited numbers of bison could have detrimental effects over the long term.

Alternatives 2 and 3 (Option B)

Analysis

In the short term the restoration of cultivated fields (and the conversion of an estimated 110 acres of cottonwood habitat) to native grassland communities would increase grassland habitat from the current estimated 8,090 acres to approximately 10,500 acres (see Table 4-1). Given current seed sources, the restored plants would be species native to the area but would not be the same genotypes as local native plants. It would be unlikely that all native species would be represented (Cole, pers. comm. 2002). There would be a major decline in forage quantity produced (compared to the forage production of the cultivated fields), but there would be a minor increase in forage quality.

Some small areas of native grassland communities on the alluvial fan in the central and east-central portions of the National Elk Refuge are in the process of converting to sagebrush shrubland habitat. Reduced numbers of elk and bison under Alternative 2 and Option B of Alternative 3 would allow that process to continue; however, 15 years would not be enough time for large-scale conversion to take place (Cole, pers. comm. 2002). In the short term it is estimated that 5,000 acres of native grassland habitat would likely convert to sagebrush shrubland habitat, and approximately 50 acres of cottonwood habitat in the north end of the refuge would convert to native grassland communities, resulting in an estimated 5,750 fewer acres as compared to Alternative 1.

Areas of native grassland communities that are too dry or on south-facing slopes would likely never convert to sagebrush shrubland habitat. In addition, wildfires under this alternative would be allowed to burn if they did not threaten structures and human safety; these fires could cause sagebrush shrubland habitat to convert to native grassland habitat.

If cheatgrass and crested wheatgrass were controlled, most native grassland habitats would remain in good condition (Cole, pers. comm. 2002).

Conclusion

In the short term there would be an estimated 2,200 more acres of native grassland habitat due mainly to the restoration of cultivated fields to native vegetation, compared to Alternative 1. In the long term, there could be an estimated 5,750 fewer acres of native grassland habitats due to conversion of native grasslands on the alluvial fan to sagebrush shrubland communities. Lower numbers of elk and bison browsing on sagebrush plants would result in substantial acreage of native grassland habitat converting to sagebrush shrubland habitat.

Alternatives 3 (Option A) and 6

Analysis

Reduced numbers of elk under this alternative, compared to Alternative 1, would allow some small areas of native grassland habitats on the alluvial fan to continue converting to sagebrush shrubland habitats (Cole, pers. comm. 2002). In the short term native grassland acreage would be similar to baseline conditions. Compared to Alternative 1, in the long term an estimated 6,000 acres would likely convert to sagebrush shrubland, resulting in an overall reduction in native grassland communities under Option A of Alternative 3 and Alternative 6 (see Table 4-1).

If cheatgrass and crested wheatgrass were controlled, native grassland habitats in most areas of the refuge would remain in good condition, and native grassland habitats in the vicinity of feedgrounds that are now in fair condition would increase moderately to good condition (Cole, pers. comm. 2002).

Conclusion

Option A of Alternative 3 and Alternative 6 would result in an estimated 6,000 fewer acres of native grassland habitat in the long term than would occur under Alternative 1.
**Alternatives 4 and 5**

**Analysis**

Under Alternatives 4 and 5 native grassland habitat would increase by an estimated 70 acres due to the decline of cottonwood communities along Flat Creek that would be browsed heavily by elk and bison compared to baseline conditions (see Table 4-1). However, as compared to Alternative 1, these alternatives would result in 840 fewer acres of native grassland habitat in the long term.

If cheatgrass and crested wheatgrass were controlled, most native grassland habitats would remain in good condition (Cole, pers. comm. 2002).

Under Alternative 4 there would be minor improvement in the fair condition of native grassland communities in the vicinity of feedgrounds due to lower bison density and reduced supplemental feeding frequency (Cole, pers. comm. 2002). As adaptive management strategies were implemented, the improvements could be moderate.

Under Alternative 5 there would be localized negative effects in the immediate vicinity of the feedgrounds, caused by trampling, trailing, and dense manure accumulation, but relative to the entire native grassland habitat on the National Elk Refuge, these effects would be minor (Cole, pers. comm. 2002).

**Conclusion**

The estimated amount of native grassland habitat on the refuge in the long term would be less by a minor amount (an estimated 840 acres) as compared to Alternative 1. Reduced numbers of elk and bison under Alternative 4 would result in a minor to moderate improvement of native grassland communities in the vicinity of feedgrounds. Reduced numbers of bison under Alternative 5 would lessen the detrimental effects of hoof damage to native grassland habitat.

**Mitigation**

Prescribed fire and allowing naturally ignited fires to burn (when under prescription) in native grassland and sagebrush shrubland habitats would help sustain these habitats in healthy condition and grassland habitat as a component of the landscape.

Eliminating prescribed fire on the refuge under Alternative 2 would result in the loss of grassland habitat over the long term due to uninterrupted vegetation succession. Potential ways to mitigate this adverse impact would require other actions (such as mechanical treatment and use of herbicides) that would conflict with the management philosophy of this alternative.

**Sagebrush Shrublands**

**Alternative 1**

**Analysis**

The condition of sagebrush shrubland communities would experience minor declines (from good to fair) in some areas of the refuge due to browsing by elk and bison (Cole, pers. comm. 2002). However, the Long Hollow sagebrush community near the McBride feedground would experience a major decline in condition. High bison numbers associated with this alternative would result in an estimated 100–200 acres of sagebrush shrubland habitat converting to native grassland habitat within 15 years (see Table 4-1).

Beyond 15 years, the conversion of an estimated 600 additional acres of sagebrush shrubland communities to native grassland communities would occur east of the Flat Creek Road near Bridger-Teton National Forest and at the base of the Gros Ventre Hills (Cole, pers. comm. 2002).

An estimated 90 acres of aspen and 110 acres of cottonwood would convert to sagebrush shrubland habitat within 15 years due to continued browsing by elk and bison. In the long term nearly all aspen habitat would convert to sagebrush shrubland habitats (Cole, pers. comm. 2002).

Most areas of native grasslands in the alluvial fan would not convert to sagebrush shrubland because browsing by current numbers of elk and growing numbers of bison under this alternative would prevent sagebrush shrubland species from becoming established.
Conclusion
In the long term sagebrush shrubland habitat would increase by an estimated 1,160 acres under Alternative 1 due primarily to the conversion of other plant communities to sagebrush shrubland habitat. The condition of sagebrush shrubland communities would generally remain in good condition (i.e., plant species diversity and vegetative structure being representative of native sagebrush communities), with some localized areas declining to fair condition due to heavy browsing and trampling.

Alternatives 2 and 3 (Option B)
Analysis
Sagebrush shrubland habitat would experience a negligible change in condition on most of the refuge compared to baseline conditions. In the short term it is estimated that 110 acres of cottonwood habitat and about 90 acres of aspen habitat would convert to sagebrush shrubland communities due to continued browsing by elk and bison (Cole, pers. comm. 2002). In the long term nearly all remaining aspen habitat (1,760 acres) would convert to sagebrush shrubland communities, with some aspen stands converting to conifer forest habitats and an additional 55 acres of cottonwood habitat converting to sagebrush shrubland. An estimated 2,400 acres of restored native grassland communities (formerly cultivated fields) would also convert to sagebrush shrubland in the long term (see Table 4-1).

Some small areas of native grassland communities on the alluvial fan in the central and east-central portions of the refuge are in the process of converting to sagebrush shrubland habitat. In the short term there would be a minor increase in sagebrush shrubland habitat near Poverty Flats due to this natural conversion. In the long term an estimated 5,000 acres of this area would likely convert to sagebrush shrubland habitat due to fewer elk and bison under these alternatives (Cole, pers. comm. 2002).

Conclusion
Compared to Alternative 1, Alternative 2 and Option B of Alternative 3 would result in an estimated 8,260 more acres of sagebrush shrubland habitat on the refuge due to the conversion of a variety of plant communities to sagebrush shrubland habitats (with a long-term average of an estimated 17,430 acres being sustained). Most of the acreage would remain in good condition.

Alternative 3 (Option A)
Analysis
Under Option A of Alternative 3 there would be 5,690 more acres of sagebrush shrublands on the refuge in the long term compared to Alternative 1. Most of the acreage would remain in good condition (Cole, pers. comm. 2002). In the short term an estimated 90 acres of aspen habitat would convert to sagebrush shrubland habitat due to continued elk browsing on woody vegetation. In the long term nearly all aspen stands (1,850 acres) would convert to sagebrush shrubland communities (see Table 4-1).

Similar to Alternative 2, 5,000 acres of native grassland habitat on the alluvial fan would convert to sagebrush shrubland communities in the long term.

Conclusion
Under Option A of Alternative 3 there would be 5,690 more acres of sagebrush shrubland habitat on the refuge in the long term compared to Alternative 1. Most of the acreage would remain in good condition.

Alternatives 4 and 5
Analysis
Under Alternatives 4 and 5 the condition of sagebrush shrubland habitat would remain in good condition (Cole, pers. comm. 2002).

In the short term an estimated 90 acres of aspen habitat would convert to sagebrush shrubland communities due to continued elk browsing on woody vegetation. In the long term nearly all of the estimated 760 acres of aspen stands outside the 1,000-acre aspen exclosure would be replaced by sagebrush shrubland habitat (see Table 4-1). Some aspen stands would convert to conifer forest habitats.

An estimated 80 acres of cottonwood habitat would also convert to sagebrush shrubland habi-
tat due to continued elk and bison browsing along upper Flat Creek, bringing the total sagebrush shrubland communities under Alternatives 4 and 5 to an estimated 8,180 acres in the short term (see Table 4-1) and an estimated 8,940 acres in the long term (Cole, pers. comm. 2002).

**Conclusion**

Under Alternatives 4 and 5 sagebrush shrubland communities on the refuge would have less acreage compared to Alternative 1 by an estimated 230 acres in the long term (resulting in a long-term estimated average of about 8,940 acres). Most of the acreage would remain in good condition, and some areas would improve due to fewer bison.

**Alternative 6**

**Analysis**

Compared to Alternative 1, there would be an estimated 3,990 more acres of sagebrush shrubland communities in the long term (see Table 4-1). Approximately 150 acres of cottonwood habitat outside the cottonwood exclosure would convert to sagebrush shrubland in the long term. The effects of Alternative 6 would be similar to Alternatives 2 and 3 in that 5,000 acres of native grasslands on the alluvial fan would convert to sagebrush shrubland in the long term. If hunting was eliminated on the northern portion of the refuge in the long term, a minor decline in condition from good to fair would likely occur.

**Conclusion**

It is estimated that approximately 5,000 acres of native grassland habitat would convert to sagebrush shrubland in the long term; however, sagebrush shrubland on the northern part of the refuge could decline from good to fair condition due to increased grazing and browsing pressure.

**Mitigation**

Mitigation measures for potential adverse impacts to sagebrush shrubland habitats would be similar to those identified above under “Native Grasslands.”

**RIPARIAN AND ASPEN WOODELANDS**

Four habitat classes have been defined for willow, aspen, and cottonwood communities, as shown in Table 4-2. In the following analysis, references are made to a particular area being in good (Class I), fair (Class II), or poor condition (Classes III and IV). Generally, the classes describe the extent of browsing, the condition of the vegetation type, and the extent of bird life as an indicator of community health.

In addition to elk and bison, numerous other herbivore species feed on woody vegetation communities, including mule deer, moose, beavers, porcupines, small mammals, birds, and insects. The individual impacts of each species have not been measured, but these impacts on woody plant communities would continue under all alternatives in addition to the impacts of elk and bison.

**Alternative 1**

**Analysis**

Woody vegetation would continue to decline under Alternative 1 both in terms of condition and acreage due to high levels of ungulate browsing (Dobkin, Singer, and Platts 2002; Diene et al. 2000). Riparian and aspen woodland stands closest to the feedgrounds would continue to be impacted the most (E. K. Cole 2002a; Dobkin, Singer, and Platts 2002). USFS and WGFD habitat improvements in Bridger-Teton National Forest adjacent to the National Elk Refuge would have little effect on habitat condition on the refuge because current levels of supplemental feeding would continue to concentrate elk and bison near the feedgrounds. Table 4-1 presents the anticipated acreage changes in riparian and aspen woodland communities on the refuge.

**Aspen Communities**

Aspen has the greatest potential for permanent loss of all woody plant community types. Most aspen communities on the National Elk Refuge are already in Class III or IV condition (Dobkin, Singer, and Platts 2002; Cole, pers. comm. 2002; Smith, Cole, and Dobkin 2004). Under Alternative 1 aspen stands would continue to shrink as conifer forest habitat and sagebrush shrubland habitat encroach due to fire suppression, combined with heavy browsing of aspen suckers by elk. Cole
### TABLE 4-2: HABITAT TYPES AND CLASSIFICATION OF WILLOW, ASPEN, AND COTTONWOOD COMMUNITIES

<table>
<thead>
<tr>
<th>Class</th>
<th>Definition</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Willows</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class I</td>
<td>Very lightly browsed (0%-10% consumption). Habitat maximizes height of willows (averaging 6.9 feet), with large crown sizes; canopy cover averages 78%. Willows grow to the edges of streams and benefit the stream aquatic ecosystem by shading streamside and producing large amounts of leaf and shoot litter-fall. Habitat has high abundance and diversity of birds, dominated by a number of bird species that are habitat specialists.</td>
<td>Good</td>
</tr>
<tr>
<td>Class II</td>
<td>Moderately browsed (11%-20% consumption). Habitat is still healthy and abundant, but the average height of willows is 4.9 feet, and canopy cover is reduced to an average of 65%. Willows generally do not grow over streamside, provide much less shade to streams, and do not provide as much cover or litter inputs into the stream. Class II habitat provides less habitat and nutrient inputs to aquatic invertebrates and fish. Fewer bird species that are habitat specialists are present.</td>
<td>Fair</td>
</tr>
<tr>
<td>Class III</td>
<td>Heavily browsed (21%-35% consumption). Willow size and production is dramatically reduced. Willows average 3.7 feet tall (only 54% of Class I willow habitat); canopy cover averages 31% of Class I. Bird species are more likely to be habitat generalists.</td>
<td>Poor</td>
</tr>
<tr>
<td>Class IV</td>
<td>Severely over-browsed (more than 35% consumption). Willow plants are short (averaging 3 feet). Some willows, severely hedged and scattered in small patches, are no taller than surrounding grass. Canopy cover averages 26%. Willow communities have lost most of their ecological function, and bird habitat is vastly different than in Class I. Class IV willow habitat on the National Elk Refuge is classified as wet meadow habitat. Habitat contains a simple bird community, dominated by habitat generalists or bird species more typical of wet meadow or native grassland habitats. On the National Elk Refuge 1,450 acres of Class III and Class IV willow habitat occurs in what are now wet meadow communities.</td>
<td>Poor</td>
</tr>
<tr>
<td><strong>Aspens</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class I</td>
<td>Lightly browsed. Robust aspen trees and shrubs of varied sizes and age classes, standing dead trees are present but not numerous, and there is a dense herbaceous layer of forbs, sedges, and grasses. Tree overstories are relatively dense. Recruitment of young trees and shrubs is evident. Young aspen trees occur at the periphery of stands and in areas where trees have died due to disturbances, such as lightning strikes or blowdown. Habitat contains a diverse bird community. Another example of a Class I stand would be a young, vigorous aspen stand that develops after a stand-replacing fire. Although most aspen stems would be of the same age class, this would still be a good condition stand.</td>
<td>Good</td>
</tr>
<tr>
<td>Class II</td>
<td>Moderately browsed. Fewer age classes of aspen trees. The overstory is sparser than Class I, but more than 50%. The understory is getting sparse, with fewer species of shrubs, forbs, sedges, and grasses. There is reduced recruitment of young trees and shrubs. Fewer bird species that are habitat specialists are present.</td>
<td>Poor</td>
</tr>
<tr>
<td>Class III</td>
<td>Heavily browsed. Sparse, decadent overstory of aspen trees, scattered clumps of decadent, pedestaled shrubs, and the complete absence of recruitment by woody species. Snags do not remain standing for long and are relatively common. Most of the birds are woodpeckers and generalist species that occur in many different habitats as well as in human-disturbed landscapes. Some Class III aspen on the National Elk Refuge has more than 50% overstory but no understory and no successful regeneration of aspen trees.</td>
<td>Poor</td>
</tr>
<tr>
<td>Class IV</td>
<td>Severely over-browsed. Few live trees, few snags, and deadwood present on the ground. The overstory is comprised of sagebrush and snowberry/rose shrubs or dry native bunch grasses. The bird community is dominated by species typical of sagebrush shrubland or native grassland habitats. Some Class IV aspen habitat is converting to conifer forest. Conifer species, which are shade tolerant, encroach on aspen habitat and shade out the aspen suckers, which need direct sunlight to grow. The combination of long periods without disturbances to provide open areas for aspen sucker growth and heavy browsing by ungulates allows conifer species to encroach.</td>
<td>Poor</td>
</tr>
<tr>
<td><strong>Cottonwoods</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class I</td>
<td>Lightly browsed. Robust cottonwood trees and shrubs of varied sizes and age classes, standing dead trees are present but not numerous, and there is a dense herbaceous layer of forbs, sedges, and grasses. Tree overstories are relatively dense, and midstories are dense and continuous. Recruitment of young trees and shrubs is evident. Habitat contains a diverse bird community.</td>
<td>Good</td>
</tr>
<tr>
<td>Class II</td>
<td>Moderately browsed. Fewer age classes of cottonwood trees. Sparser overstory than class I, but more than 50%. The understory is getting sparse, with fewer species of shrubs, forbs, sedges, and grasses. There is reduced recruitment of young trees and shrubs. Fewer bird species that are habitat specialists are present.</td>
<td>Fair</td>
</tr>
<tr>
<td>Class III</td>
<td>Heavily browsed. A sparse, decadent overstory of cottonwood trees; scattered clumps of decadent, pedestaled shrubs; and the complete absence of recruitment by woody species. Snags do not remain standing for long and are relatively common. Most of the birds are woodpeckers and generalist species that occur in many different habitats as well as in human-disturbed landscapes.</td>
<td>Poor</td>
</tr>
<tr>
<td>Class IV</td>
<td>Severely over-browsed. Few live trees, few snags, and deadwood present on the ground. The overstory is comprised of sagebrush and snowberry/rose shrubs or dry native bunch grasses. The bird community is dominated by species typically occurring in sagebrush shrubland or native grassland habitats.</td>
<td>Poor</td>
</tr>
</tbody>
</table>

estimates that an additional 5%–10% of aspen habitat (90–185 acres) would be lost in the next 15 years (E. K. Cole 2002a). For the sake of simplicity, and to avoid overestimating the loss of aspen trees, the most conservative estimate of 5% loss of aspen habitat has been used in all alternatives.

In the long term, the pace of this loss would likely accelerate because many mature aspen stems are about 120 years old, and their maximum life span is about 150 years (Cole, pers. comm. 2002).

Fire may reduce succession of aspen to conifers in some areas, but DeByle, Bevins, and Fischer (1987) noted that fire frequencies of 100–300 years were adequate for retaining aspen. The degree of aspen recovery in refuge enclosures and in areas of Jackson Hole with lower ungulate densities suggests that stands can regenerate and remain viable even without the stimulation of fire (Smith, Cole, and Dobkin 2004).

**Willow Communities**

Willow habitats are already in poor condition (Class III or IV) in the southern part of the refuge (Dobkin, Singer, and Platts 2002; Smith, Cole, and Dobkin 2004), and under Alternative 1 the condition of willow stands in this area would continue to decline in the short and long terms due to heavy browsing by elk. Approximately 50 acres of willow habitat in the southern part of the refuge, currently in Class III condition, would convert to suppressed willow plants in wet meadow habitat (Class IV) within 15 years and would eventually disappear (Cole, pers. comm. 2002). In the long term the National Elk Refuge would lose existing rootstock of approximately 1,450 acres of suppressed willow plants in the southern end of the refuge that now exist in wet meadow habitat, making any future reestablishment difficult without major soil disturbance.

There would be no acreage change for the 250 acres of willow habitat in the northern end of the refuge in the short term, but an estimated minor decline in the condition of willow stands would be expected (Cole, pers. comm. 2002).

**Cottonwood Communities**

An estimated 110 acres of cottonwood habitat would convert to native grassland communities, and an additional 110 acres would convert to sagebrush shrubland habitat. In the short term, an estimated major decline in the condition of cottonwood stands along Flat Creek would continue beyond already poor conditions, and loss of acreage of cottonwood communities could be possible close to the McBride feedground as some large mature trees succumb to girdling from bison rubbing. Other deciduous shrub species such as willow, serviceberry, chokecherry, rose, and gooseberry would continue to decline in height and density. Approximately 220 acres of cottonwood communities occurring along upper Flat Creek would eventually be lost (Cole, pers. comm. 2002).

Approximately 870 acres of cottonwood stands along the Gros Ventre River would experience an estimated minor decline in condition due to elk and bison browsing, but no acreage change is expected in the next 15 years (Cole, pers. comm. 2002). In the long term, some limited acreage loss of cottonwood habitat would be likely in the Gros Ventre River corridor.

**Conclusion**

In the short term an additional 50 acres of willow habitat would convert to suppressed willow plants in wet meadows habitat on the refuge. In the long term the remnant willows on about 1,500 acres of wet meadow habitat (Class IV willow habitat) would die, leaving little chance for healthy willow habitat to recover on its own. The condition of aspen communities would continue to decline, and it is estimated that most and possibly all stands would eventually die out. Cottonwood communities would decline in condition, and an estimated 220 acres of cottonwood habitat would be lost along upper Flat Creek. Remaining stands would be in Class I and II condition.

**Alternative 2**

**Analysis**

The northern end of the refuge would most likely see an estimated moderate increase in elk and bison use during fall and early winter compared to Alternative 1 due to the elimination of hunting and the eventual elimination of supplemental feeding on the refuge (Cole, pers. comm. 2002). Even though habitat improvement in Bridger-Teton National Forest would draw elk and bison
from the refuge (concurrent with winter feeding being phased out), this would likely not hinder the increased use and densities of elk and bison at the northern end of the refuge. Eliminating hunting on the refuge would allow elk and bison to make additional use of this area.

There are two possible scenarios for Alternative 2 after cessation of supplemental feeding. Under both scenarios, elk and bison populations would fluctuate from year to year depending on predation, disease, and the number of animals harvested on surrounding lands (Cole, pers. comm. 2002).

- Scenario 1: Without supplemental feeding elk and bison would stay on the refuge only until standing forage was exhausted or inaccessible, which would happen when elk and bison numbers were high and/or winters were severe (Cole, pers. comm. 2002). In response, the Wyoming Game and Fish Department could increase its supplemental feeding program on the Gros Ventre feedgrounds or open a new feedground in Buffalo Valley. The state could also cull bison and have depredation hunts for elk to mitigate private property damage. These factors could result in fewer elk and bison on the refuge, but numbers and duration of stays on the refuge in some years might still be too high to allow full recovery of woody plant communities.

- Scenario 2: The cessation of supplemental feeding could result in elk and bison roaming farther for food and eventually establishing migration routes into the Green River basin and the Red Desert. Therefore, elk and bison would spend less time on the refuge, allowing an overall improvement in the condition of woody plant communities. Scenario 2 is not portrayed in Table 4-1 because it would not occur without the cessation of supplemental feeding in the Gros Ventre River drainage and South Park and possibly on other state feedgrounds. The migration scenario would also not occur without the cooperation of public and private organizations and individuals.

Aspen Communities

In scenario 1 there would be an estimated moderate decline in the condition of aspen habitat beyond the already poor condition of aspen stands. A moderate decline in aspen condition in the short term would result from the continued failure of aspen suckers to escape browsing and grow to full height. In 30 or more years most mature aspen stems would disappear, and under Alternative 2 nothing would grow out of the browse zone to replace them. Eventually, most of the current estimated 1,850 acres of aspen habitat would convert to sagebrush shrubland communities, and some aspen stands would convert to conifer-dominated communities.

If scenario 2 occurred, there would be minor improvement in the condition of aspen habitat (Cole, pers. comm. 2002). Depending on how many elk would migrate to other wintering areas, some aspen stands could survive in the long term.

Willow Communities

For the full recovery of approximately 1,190 acres of willow habitat in the southern end of the refuge (currently in Class III or IV condition, including 1,140 acres of suppressed willows that are classified as wet meadow habitat), elk numbers would have to be reduced to between 2,400 and 2,700 for 6 to 10 years; recovery would take an estimated 25 to 30 years (Singer and Zeigenfuss 2003). However, if elk numbers were low for a period of 3 years, it would be enough time for some willow stems to grow out of the browse zone (Cole, pers. comm. 2002). As elk numbers fluctuated above and below the 2,400–2,700 range over a period of years, height release of willows would be sporadic, and it would likely take a number of decades to reach full recovery to Class II or I condition.

Under scenario 1 if a major disturbance or intervention (such as fencing, flooding, return of beavers) did not occur in the short or long term, most wet meadow areas where willow plants are suppressed could remain suppressed as elk continued to browse in these areas. However, with fewer elk on the National Elk Refuge in most winters, willow habitat could increase by an estimated 100 acres in the south end of the refuge within 15 years (see Table 4-1). Approximately 250 acres of willow stands on the northern end of the refuge would likely remain in fair to good condition (Class I or II). Although elk numbers would be lower under Alternative 2, improvement of Class II stands to Class I condition would not be likely.
due to the cessation of hunting on the refuge and due to the north end being a safe zone from hunting in Bridger-Teton National Forest. Therefore, these north end willow stands would continue to be browsed by elk seeking safety from hunting.

Under scenario 2 if migration occurred in the long term, and very few elk remained on the refuge in the winter, Alternative 2 would result in willow stands becoming dominant in the southern end of the refuge on what is now wet meadow habitat with suppressed willow plants. Approximately 250 acres of willow stands in the northern end of the refuge would improve by a moderate amount, and possibly all willow communities would achieve Class I condition.

**Cottonwood Communities**

Despite the change in management and numbers of elk and bison under scenario 1, the effects on the cottonwood community on upper Flat Creek would be similar to Alternative 1.

Under scenario 2 there would be moderate to major improvement in the condition of cottonwood communities along the upper portion of Flat Creek in the long and short terms, and a possible minor acreage increase in the long term since many elk and bison would migrate to other wintering areas. This would allow a minor improvement in the condition of cottonwood habitat along the Gros Ventre River. Cottonwood establishment and persistence would also benefit from increased water flows in Flat Creek due to cessation of irrigation diversion for the cultivated fields (Cole, pers. comm. 2003). Cottonwood habitat along upper Flat Creek would achieve Class I or II condition compared to the current Class III or IV condition.

**Conclusion**

Compared to Alternative 1, if the majority of elk in the Jackson elk herd unit continued to winter within the herd unit boundaries, Alternative 2 would result in an estimated 150 more acres of Class I or II willow habitat on the refuge and an estimated 400 acres of willow habitat being sustained over the long term. However, similar to the effects of Alternative 1, most of the 1,850 acres of aspen habitat would be lost in the long term, and cottonwood habitat would decline by an estimated 220–330 acres on the refuge. The condition of remaining cottonwood stands would be Class I or II.

If a large portion of the elk that otherwise would have wintered on the refuge migrated to other wintering areas, elk numbers on the refuge could be reduced sufficiently to allow an increase in Class I or II willow habitat by nearly 1,500 acres. Other willow stands would improve in condition (for a total of about 1,750 acres), and cottonwood and aspen communities would retain their current acreage (1,090 and 1,850 acres, respectively) and would improve in condition.

**Alternative 3**

**Analysis**

Lower numbers of elk with decreased supplemental feeding would result in overall moderate improvement in riparian and aspen woodlands in the short and long terms (Cole, pers. comm. 2002). Eliminating hunting in the northern portion of the refuge would minimize the benefits of reduced elk numbers on the refuge because the elk would learn which part of the refuge was a safe zone and would spend more time there during the fall and early winter. In the long term elk and bison numbers on the refuge would be low enough to allow elk and bison to winter on the refuge without supplemental feeding in all but the most severe winters. Under these conditions elk and bison would likely not wander far beyond refuge boundaries, although more elk could make greater use of national forest land immediately east of the refuge (e.g., within about 5 miles).

**Aspen Communities**

Elk numbers on the refuge under this alternative would be reduced, but they would likely spend more time at the north end of the refuge (during fall and winter, in particular) due to the reduced frequency of supplemental feeding and hunting closures in the northern portion of the refuge; this would reduce the benefits of lower numbers of elk (Cole, pers. comm. 2002) compared to Alternative 1.

Over the next 15 years, despite lower elk and bison numbers under Alternative 3, there would be an estimated moderate decline in the condition of aspen communities over their already poor condi-
tion (Cole, pers. comm. 2002). Aspen acreage would decrease by an estimated 5% (90 acres) during the next 15 years due to continued browsing by elk (see Table 4-1). In 30 or more years mature aspen stems would disappear, and very few if any saplings would grow out of the browse zone to replace them. Most of these stands would convert to sagebrush shrubland habitats, and some would convert to conifer-dominated communities.

If many elk were to migrate out of the Jackson Hole area in the winters, the effects on aspen communities would be similar to the effects of scenario 2 under Alternative 2.

**Willow Communities**

Willow habitat could increase by an estimated 730 acres in the south end of the National Elk Refuge in the short term compared to baseline conditions as remnant willow plants converted to Class I or II willow communities. There would be an increase in willow habitat (see Table 4-1) because elk numbers would be sustained below 2,000 and bison numbers below 1,000. Compared to Alternative 1, Alternative 3 would have an estimated 1,500 more acres of willow habitat in Class I or II condition (and some in Class III condition) on the southern part of the refuge in the long term. Willow acreage would not increase on the northern end of the refuge because all sites suitable for willows are currently occupied by willow stands.

**Cottonwood Communities**

In the short term there would be a moderate improvement in the condition of the cottonwood communities along the upper portion of Flat Creek because the frequency of feeding on the National Elk Refuge would be reduced (Cole, pers. comm. 2002). No acreage change is expected from baseline conditions. Portions of the riparian zone would potentially become dense thickets of cottonwood, willow, serviceberry, and choke-cherry, potentially shading out and causing a decrease in the herbaceous vegetation in the thickest patches of woody vegetation. However, this would depend on the frequency of emergency feeding operations. At least four consecutive years without feeding would be necessary for cottonwood to successfully escape browsing pressure (Cole, pers. comm. 2002). In the long term, there might be a slight acreage increase in the Flat Creek cottonwood zone and moderate improvement in condition.

The Gros Ventre River cottonwood community would experience negligible change in condition or acreage in the short and long terms because, although elk numbers would be lower, elk would be using the area more because it would be a safety zone during hunting season.

**Conclusion**

Aspen communities would decrease by as much as 1,850 acres in the long term, which is similar to Alternative 1. Class I or II willow habitat on the refuge would be more by an estimated 1,500 acres in the long term (for a total of about 1,750 acres) as compared to Alternative 1. The amount of cottonwood habitat would remain similar to baseline conditions (about 1,090 acres), which is 240 acres more than cottonwood communities under Alternative 1.

**Alternatives 4 and 5**

**Analysis**

Maintenance of current elk hunting areas, the addition of exclosures (under Alternatives 4 and 5), and lower elk densities (under Alternative 4) could promote an estimated major improvement of deciduous woody plant communities in the northern end of the refuge (Cole, pers. comm. 2002). The improvement would be more pronounced if winter range improvement projects were undertaken immediately east of the refuge (e.g., within 5 miles) and other locations in the national forest or as adaptive management strategies were implemented (e.g., more fencing or rotating of exclosures).

**Aspen Communities**

Inside the 1,000-acre exclosure on the north end of the refuge there would be a major improvement in aspen condition from Class III or IV to Class I or II, and an estimated 5% acreage increase could be anticipated (Cole, pers. comm. 2002). Fire or other large-scale disturbance of mature aspen stems could facilitate replacement of mature stems by causing large-scale growth of aspen suckers, although dense growth of aspen suckers
Impacts on Habitat: National Elk Refuge

could shade out and eliminate most herbaceous vegetation.

Outside the exclosure there would be a minor decrease in the already poor condition of aspen and about a 5% acreage (90 acres) decrease over 15 years due to continued browsing by elk (see Table 4-1). In the long term approximately 850 acres of aspen habitat would convert to sagebrush shrubland and conifer habitats unless other actions were taken under Alternative 4.

Without a 1,000-acre aspen exclosure on the north end of the refuge, upland aspen stands would continue to shrink as mature aspen trees continued to die without being replaced by aspen suckering, and as stands were subsequently replaced by conifer forest habitat and sagebrush shrubland habitat. There would be an estimated minor decline in the already poor condition that currently exists (Cole, pers. comm. 2002). An estimated 5% of aspen communities (90 acres) would be lost in the next 15 years. In the long term most aspen stands would be lost and replaced with sagebrush shrubland and conifer forest habitat.

Willow Communities

In the short term a 500-acre exclosure on the southern end of the refuge would lead to an estimated major improvement in the condition of 250 acres of willow communities from Class III or IV to Class I or II. Fire within the exclosure would increase willow densities and speed up the development of willow within gaps. Beaver reintroduction, either natural or by release, to the exclosure area would facilitate willow development from seed on the exposed mud flats that old beaver ponds produce and would further increase willow cover within the exclosure (Singer and Zeigenfuss 2003; Peinetti, Kalkhan, and Coughenour 2002; Cole, pers. comm. 2006). Over the long term (assuming that additional restoration activities were implemented), willow habitat in Class I condition would increase to an estimated 500 acres within the exclosure.

Willow communities outside the exclosure in the southern part of the refuge would continue to decline in condition because elk would still browse, and elk densities would not be low enough to allow these willows to regenerate, unless other actions were implemented under Alternative 4. In the long term, willow plants outside the exclosure would die out as existing root systems continued to deteriorate (Cole, pers. comm. 2002). An estimated 270 acres of willow habitat in Class II or III condition would continue outside exclosures, mostly on the northern end of the refuge.

If Alternatives 4 and 5 did not include a 500-acre willow exclosure in the southern part of the refuge, willow habitat would continue to decline in condition by a minor amount in the short term due to continued browsing by elk. The remaining acreage of willow habitat on the south end (approximately 50 acres) would convert to wet meadow habitat in the long term (Cole, pers. comm. 2002).

With a 1,000-acre aspen exclosure there would likely be increased pressure on willow and other woody vegetation communities outside the exclosure because elk would browse more heavily on whatever woody vegetation was accessible. There would be a minor decline in the condition of willow habitat in the Gros Ventre River corridor due to the aspen exclosure (Cole, pers. comm. 2002).

Without a 1,000-acre aspen exclosure under Alternative 4, there would be a negligible decline in the condition of willow habitat on the northern end of the refuge compared to baseline conditions. Without a 1,000-acre aspen exclosure under Alternative 5, willow habitat on the northern end of the refuge would experience a minor decline in condition with some conversion of willow communities to wet meadow habitat on wetter sites, and to spotted knapweed or upland grass on drier sites (Cole, pers. comm. 2002).

Cottonwood Communities

A 100-acre cottonwood exclosure would extend farther out into the floodplain than cottonwood communities currently occur, which could increase the width of the riparian corridor, depending on flood events. There would be major improvement in the condition of cottonwood communities inside the 100-acre Flat Creek exclosure and a minor acreage increase in the short and long terms (Cole, pers. comm. 2002).

Along the upper portion of Flat Creek, outside the exclosure, there would be a major decline in the condition of cottonwood habitat over the already
poor condition (Class III or IV) because elk and bison would continue to browse the accessible cottonwood habitat, and fewer elk and bison, along with reduced supplemental feeding, would not mitigate the increased pressure. In the long term an estimated 150 acres of cottonwood habitat could be lost along Flat Creek (see Table 4-1). Implementing adaptive management strategies under Alternative 4 could limit declines.

In the short and long terms, if Alternatives 4 and 5 did not include a 100-acre cottonwood exclosure, an estimated major decline in the condition of these cottonwood stands along upper Flat Creek would continue beyond already poor conditions, and an estimated 220 acres of cottonwood communities close to the McBride feedground could be lost (Cole, pers. comm. 2002).

A 1,000-acre aspen exclosure in the northern end of the refuge would likely increase browsing pressure on cottonwood and other woody vegetation outside the exclosure because elk would browse more heavily on whatever woody vegetation remained accessible. Under Alternative 4 increased browsing pressure on cottonwood communities along the Gros Ventre River could nullify the benefits of reduced elk numbers, and there would be negligible change in the condition of cottonwood habitat (Cole, pers. comm. 2002). With a 1,000-acre aspen exclosure under Alternative 5, many cottonwood communities along the Gros Ventre River would decline from good or fair condition (Class I or II) to poor condition (Class III or IV). Cottonwood habitat along the Gros Ventre River would persist in the long term, but acreage could be reduced by a minor amount.

If Alternative 4 did not include a 1,000-acre aspen exclosure, cottonwood stands along the Gros Ventre River would experience an estimated minor increase in condition due to fewer browsing elk and bison, but no acreage change is expected in the next 15 years (Cole, pers. comm. 2002). In the long term cottonwood habitat would likely persist in the Gros Ventre River corridor at about the same acreage as baseline conditions and with minor improvement in condition. The areas within the Gros Ventre River riparian zone where cottonwood suckers and seedlings are capable of growing out of the browse zone would likely increase slightly.

If Alternative 5 did not include a 1,000-acre aspen exclosure, cottonwood stands along the Gros Ventre River would experience an estimated minor decline in condition, but the decline would be less than with an aspen exclosure. Some cottonwood stands could decline from Class I or II to Class III or IV. However, no acreage change would be expected in the next 15 years (Cole, pers. comm. 2002).

**Conclusion**

It is estimated that the amount of willow habitat in Class I or II would be more by an estimated 520 acres in the long term compared to Alternative 1 (for a total of about 770 acres). The amount of aspen habitat on the refuge could decrease by an estimated 850 acres in the long term, leaving an estimated 1,000 acres compared to almost no aspen habitat under Alternative 1. The amount of cottonwood habitat could decrease from the current 1,090 acres by about 150 acres, leaving an estimated 940 acres. Most of the remaining willow and aspen habitat would likely be in large blocks formed by the enclosures and would be in Class I condition. Remaining cottonwood habitat would be in Class II or III condition. Implementing adaptive management strategies under Alternative 4 could result in improved conditions to Class III or better in the long term.

**Alternative 6**

**Analysis**

Several factors would promote a major improvement in riparian and aspen woodland communities on the refuge; those factors are continued elk hunting in the near short term, the addition of rotating temporary exclosures that would allow nearly all to all of the existing aspen habitat to recover, a permanent exclosure that would protect 100 acres of cottonwood communities, and lower elk densities (Cole, pers. comm. 2004). The improvement would be more pronounced if winter range improvement projects were undertaken immediately east of the refuge (e.g., within 5 miles) and other locations in the national forest.

**Aspen Communities**

Under Alternative 6 an estimated 600 acres of aspen would be enclosed in several exclosures of
varying sizes. Aspens in these exclosures would be burned or cut to stimulate regeneration. After approximately 10 years the fencing would be removed, and another 600 acres of aspen would be enclosed. These temporary exclosures would be rotated until all aspen habitats on the refuge were treated and protected from browsing for approximately 10 years. The objective on the refuge would be no net loss of aspen. If it appeared that some unenclosed aspen stands would be lost before 10 years had passed, additional acreage would be enclosed beyond the initial 600 acres. In the long term (an estimated 30 years), after all aspen stands on the refuge had presumably recovered, the exclosures would be removed. Monitoring of aspen habitat condition would continue, and if it appeared that ungulates were having negative impacts on aspen communities, exclosures would continue to be temporarily erected and rotated at appropriate intervals to ensure the continued existence of Class I or II aspen habitat on the refuge.

Inside the aspen exclosures there would be a major improvement in aspen condition from Class III or IV to Class I or II, and an estimated 5% acreage increase could be anticipated.

If Alternative 6 did not include 600 acres of rotating temporary aspen exclosures, upland aspen stands would continue to shrink as mature aspen trees continued to die without being replaced by aspen suckering, and as stands subsequently were replaced by conifer forest and sagebrush shrubland. There would be an estimated minor decline in the condition of aspen stands over the already poor conditions (Class III or IV) currently (Cole, pers. comm. 2002), and an estimated 5% of aspen communities (90 acres) would be lost in the next 15 years.

Without aspen exclosures, the loss of aspen habitat loss would likely accelerate in the long term, with aspen communities eventually disappearing.

**Willow Communities**

Willow habitat on the southern part of the refuge would not be protected by an exclosure; instead, elk numbers would be lowered to 2,400–2,700 animals. Singer and Zeigenfuss (2003) predicted that lowering elk numbers to this level would reduce browsing pressure enough to allow willows to recover to Class I or II condition without fencing, but they indicated that suppressed willow plants in wet meadow habitats (Class IV) might need active disturbance in the form of flooding, fencing, burning, or the return of beavers to fully recover. If monitoring indicated that willow habitat was not going to recover in a reasonable amount of time with reduced elk numbers, elk numbers would be further reduced until sufficient recovery occurred (but would not be reduced below 1,000–2,000 elk). As a last resort, one or more exclosures would be erected in areas where willow habitat was not recovering.

The effects of Alternative 6 on willow communities would be similar to Alternative 3. After elk numbers were reduced, the condition of willow communities would be expected to improve from Class III or IV to Class I or II. Willow canopy cover in most areas occupied by willows would likely increase to about half of the objective level of 60%–85% in the short term, and canopy cover would reach objective levels in the long term.

**Cottonwood Communities**

The effects of a 100-acre cottonwood exclosure under Alternative 6 would be similar to Alternative 4.

If Alternative 6 did not include a 100-acre cottonwood exclosure, in the short and long terms impacts would be as described in Alternative 4.

Without a 600-acre aspen exclosure there would not be increased browsing pressure on cottonwood stands due to elk concentrating on whatever woody vegetation was accessible; therefore, cottonwood stands along the Gros Ventre River would experience an estimated minor increase in condition due to fewer browsing elk under Alternative 6. No acreage change would be expected over the next 15 years (Cole, pers. comm. 2002). In the long term cottonwood habitat would likely persist in the Gros Ventre River corridor at about the same acreage as baseline conditions and with minor improvement in condition.

**Conclusion**

The amount of aspen habitat on the refuge would remain similar to baseline conditions (1,850 acres), but most aspen stands would improve in condition.
to Class I or II as compared to almost no aspen habitat under Alternative 1. It is estimated that the amount of willow habitat in Class I or II would increase by an estimated 1,500 acres in the long term compared to Alternative 1 (for a total of about 1,750 acres). The amount of cottonwood habitat would decrease from the current 1,090 acres by about 150 acres, leaving an estimated 940 acres in Class I or II, an estimated 70 acres more than under Alternative 1.

Mitigation
The alternatives include measures to mitigate the adverse impacts of excessive elk browsing on woody vegetation. With respect to elk, habitat treatments would be coordinated with the phase-out of supplemental feeding on the refuge (Alternatives 2, 3, 4, and 6), and agencies could avoid treating willow and cottonwood communities in areas where regrowth would be heavily browsed.

Conifer Forests
All Alternatives
Analysis
Conifer forest habitat covers approximately 160 acres on the National Elk Refuge.

No significant acreage change of conifer forest communities would be expected under any alternative (see Table 4-1). There would likely be a minor increase in conifer cover in most aspen stands due to natural succession in the absence of fire combined with differential browsing pressure on palatable deciduous species.

Conclusion
No significant acreage change in conifer forest would be expected under any alternative.

Mitigation
No mitigation would be necessary.

Cultivated Fields
Irrigated and non-irrigated acreage, total and herbaceous forage production, and pounds of forage produced per acre would be similar for baseline conditions and Alternative 1.

Alternative 1
Analysis
Forage production on about 2,400 acres of cultivated fields on the refuge would remain similar to past levels (an average of about 3,300 tons per year of herbaceous forage) if sufficient personnel could be found to perform flood irrigation work.

Forage production could increase in the future if

- the U.S. Fish and Wildlife Service discovered more desirable plant species with greater production potential
- sprinkler irrigation was increased (up to a maximum of 260 acres under existing authorization), which would increase forage production; at a minimum of 5,000 pounds per acre, forage could increase by 650 tons per year or more (see Table 4-3)

Forage production could decrease in the future because of

- the difficulty of efficiently managing water on the refuge using flood irrigation due to the porous refuge soils, poor condition of ditches and headgate structures, and limited number of irrigators
- the nonnative plant species invading approximately 230 acres of cultivated fields near the town of Jackson could reduce forage production by about 80%–90% in that area in the long term

Current levels of elk wintering on the refuge would not impact cultivated fields in the future. If bison numbers continued to grow, they could reach a point where they could not be prevented from entering the southern part of the refuge and could not be hazed off the refuge in the spring. It is possible that bison would feed on the forage during the growing season, and this could cause major declines in forage available for the following winter season; but even if the increased numbers of bison only fed on the cultivated fields during the winter, this would still mean less standing forage available for elk.
TABLE 4-3: ESTIMATED FARMED ACREAGES AND ASSOCIATED FORAGE PRODUCTION LEVELS IN CULTIVATED FIELDS — NATIONAL ELK REFUGE

<table>
<thead>
<tr>
<th>Acres/Year (1992–2001)</th>
<th>Baseline</th>
<th>Alternative 1</th>
<th>Alternatives 2 and 3 (Option B)</th>
<th>Alternative 3 (Option A)</th>
<th>Alternatives 4, 5, and 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flood Irrigated</td>
<td>930 acres</td>
<td>930 acres</td>
<td>NA</td>
<td>990 acres</td>
<td>500 acres</td>
</tr>
<tr>
<td>Sprinkler</td>
<td>60 acres</td>
<td>60 acres</td>
<td>NA</td>
<td>0</td>
<td>400 acres</td>
</tr>
<tr>
<td>Sprinkler2</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>700 acres</td>
</tr>
<tr>
<td>Non-Irrigated</td>
<td>1,410 acres</td>
<td>1,410 acres</td>
<td>(2,400 acres)²</td>
<td>1,410 acres</td>
<td>800 acres</td>
</tr>
<tr>
<td>Total Acres</td>
<td>2,400 acres</td>
<td>2,400 acres</td>
<td>(2,400 acres)²</td>
<td>2,400 acres</td>
<td>2,400 acres</td>
</tr>
</tbody>
</table>

| Acres/Year (Driest Year)² | Flood Irrigated | 830 acres | 830 acres | NA | 830 acres | 500 acres |
| Sprinkler              | 60 acres       | 60 acres  | NA        | 0  | 400 acres  |
| Sprinkler2             | NA             | NA       | NA        | NA | 700 acres  |
| Non-Irrigated          | 1,510 acres    | 1,510 acres | (2,400 acres)² | 1,570 acres | 800 acres |

| Tons of Forage/Year   | Flood Irrigated | 1,900 tons | 1,900 tons | NA | 2,000 tons | 1,000 tons |
| Sprinkler Irrigated   | 1,100 tons     | 1,100 tons | NA        | 1,100 tons | 600 tons   |
| Wettest Year          | 5,900 tons     | 5,900 tons | NA        | 5,900 tons | 1,500 tons |
| Sprinkler Irrigated   | 5,000 lbs/ac objective | 180 tons | 180 tons | NA | 180 tons | 1,000 tons |
| 2,500 lbs/ac objective | NA             | NA       | NA        | NA | 900 tons   |
| Non-Irrigated         | 1,200 tons     | 1,200 tons | (1,300 tons)² | 1,200 tons | 700 tons   |
| Wettest Year          | 500 tons       | 500 tons  | NA        | 500 tons | 200 tons   |
| Total Tons for All Fields | 3,300 tons | 3,300 tons | (1,300 tons)² | 3,200 tons | 3,600 tons |

| Total Lbs./Acre All Fields | Average Year | 2,800 lbs./ac. | 2,800 lbs./ac. | (1,100 lbs./ac.) | 2,700 lbs./ac. | 3,000 lbs./ac. |
| Wettest Year             | 5,500 lbs./ac. | 5,500 lbs./ac. | 0              | 1,300 lbs./ac.  | 2,300 lbs./ac. |

1. There was no sprinkler irrigation system on the National Elk Refuge in 1993.
2. Objectives for the amount of forage produced with sprinkler irrigation would be 5,000 lbs/ac on 400 acres and 2,500 lbs/ac on 700 acres under Alternatives 4, 5, and 6. The forage would be better quality with a 2,500 lbs/ac objective.
3. Forage production for these fields in Alternative 2 are accounted for in native grassland habitats.
4. Driest year estimates for the current situation are based on figures from 2001.
5. Wettest year estimates for the current situation are based on figures from 1993, except for sprinkler irrigated acreage, which was 0 in 1993.

**Conclusion**

Forage production on about 2,400 acres of cultivated fields on the refuge would remain similar to past levels (an average of about 3,300 tons per year of herbaceous forage) if sufficient personnel could be found to perform flood irrigation work. If sprinkler irrigation was extended to a maximum of 260 acres, forage production could increase by an estimated minimum of 650 tons per year (an increase of about 18% over the average 3,300 tons per year). Plant species diversity would remain low compared to native species composition, and plant communities would continue to be dominated by nonnative species.

**Alternatives 2 and 3 (Option B)**

**Analysis**

Prior to Euro-American settlement, the areas on the refuge that are now cultivated fields were
most likely sagebrush shrubland. If these fields were restored to native habitat, as called for in Alternative 2, refuge management would endeavor to reestablish sagebrush shrubland plant species. This is a very slow-growing plant community, and initially, native grasses would dominate replanted sites. After about 25 years (or longer) sagebrush would begin to dominate.

Over the course of 15 years, as irrigation was phased out and approximately 2,400 acres of cultivated fields were restored to native vegetation, forage production would become similar to what currently exists on native grasslands. After 25 years or longer, many of these rehabilitated native grasslands would convert to a sagebrush shrubland habitat (Cole, pers. comm. 2002). Based on forage production on other refuge grasslands, it is estimated that in the short term these restored grasslands would produce about 1,300 pounds per acre or 1,600 tons per year (see Table 4-3). Herbaceous forage production on native grasslands (i.e., forage that is most palatable to ungulates) would be an estimated 1,100 pounds per acre or about 1,400 tons per year, which is an estimated 60% reduction compared to Alternative 1.

Reduced forage production on what are now cultivated fields could have large effects on the refuge’s ability to overwinter elk and bison because these fields occur in the southern part of the refuge, which receives the least amount of snow and is therefore more accessible to grazing elk and bison. Forage in the northern portion of the refuge is often unavailable to elk and bison because of greater snow depth.

After the cultivated fields were totally restored to native grasslands and sagebrush shrublands, forage production would depend totally on plant species characteristics, the timing and amount of precipitation in a given year, insect infestation, invasion of nonnative plant species, and other environmental factors. The loss of agricultural land on the refuge is not subject to the Farmland Protection Policy Act.

Conclusion
Cultivated plant species on all 2,400 acres of existing cultivated fields would be converted to native grassland habitat. Alternative 2 and Option B of Alternative 3 would result in less herbaceous forage production on the approximately 2,400 acres that are now cultivated by an estimated 60% compared to Alternative 1.

Alternative 3 (Option A)
Analysis
Under Option A an average of approximately 990 acres would be flood irrigated each year, and about 1,410 acres each year would not be irrigated. Total forage production for the entire 2,400 acres of cultivated land would be an estimated 3,200 tons per year on a 10-year average or approximately 2,700 pounds per acre (see Table 4-3). This would be similar to Alternative 1.

Although forage production under Option A would be similar to Alternative 1, with emergency only supplemental feeding and bison and elk hunting or other public access on the southern end of the refuge, lower numbers of elk and bison would be grazing on these fields.

Conclusion
The effects of Option A would be similar to Alternative 1.

Alternatives 4, 5, and 6
Analysis
Under Alternatives 4, 5, and 6 forage production on cultivated fields would increase from approximately 3,300 tons per year under Alternative 1 to an estimated average 3,600 tons per year (see Table 4-3 and the “Irrigation Project Areas of the NER, Alternatives 4–6”).

Although the amount of forage produced with more sprinkler irrigation would not be dramatic, the resulting forage would be more palatable and of higher quality. Sprinkler irrigation would allow refuge managers more flexibility in determining the amount and timing of water application, which affects the growth and nutritional value of forage. Sprinklers also increase the efficiency of irrigation by requiring less water from creeks, and fewer staff are needed to implement the program. The modifications to the flood irrigation system would result in only a minor increase in forage production on the approximately 500 acres that would continue to be flood irrigated each year because
Map

Irrigation Project Areas of the NER
efficiency is as related to soil characteristics and available labor as it is to structural improvements.

A similar amount of forage would be produced on cultivated fields under Alternatives 4, 5, and 6; however, different numbers of animals would be consuming this forage under each alternative.

**Conclusion**

Alternatives 4, 5, and 6 would result in more palatable and higher quality forage produced on cultivated fields compared to Alternative 1.

**Mitigation**

The loss of the refuge’s cultivated fields under Alternative 2 and Option B of Alternative 3 would reduce forage production on the refuge, but this would be offset by fewer elk and bison, increased distribution of animals, and possibly migration to other wintering areas. No additional mitigation would be necessary to address the reduction in forage production on the refuge, and no other negative impacts are anticipated.

To mitigate the effects of grasshoppers on forage production, integrated pest management that includes the use of insecticides and baits could be considered.

**Total and Herbaceous Forage Production on the National Elk Refuge Outside Exlosures**

**Impacts of the Alternatives**

Acreage totals have been rounded to the nearest 10 acres and tons, and pounds per acre have been rounded to the nearest 100 tons or 100 pounds per acre. Therefore, forage production numbers may be slightly different than figures cited in Chapter 3.

**Alternative 1**

**Analysis**

The 10-year average for total forage production for all habitats on the National Elk Refuge (24,250 acres) is estimated at 22,900 tons of total forage and 19,000 tons of herbaceous forage. Projected forage production under Alternative 1 would be 23,000 tons of total forage production in the short term and 22,600 tons in the long term. Projected herbaceous forage production would be 18,800 tons in the short term and 18,500 tons in the long term. These figures represent a 100–500 ton decline (a decrease of 0.5%–3%) in total and herbaceous forage production. Forage production declines would be due primarily to the decrease of woody vegetation as large numbers of elk and bison browsed in riparian and aspen woodland habitats.

**Conclusion**

Under Alternative 1 refuge-wide total forage production would be negligibly less in the short and long terms compared to baseline conditions. Herbaceous forage production would also decline by a negligible amount (0.5%–3%) in the short and long terms.

**Alternative 2**

**Analysis**

The estimated average total forage production for all habitats on the National Elk Refuge (24,250 acres) would be 21,300 tons in the short term, a decline of 1,600 tons (7%), and 22,100 tons in the long term, a decline of 800 tons (4%) as compared to baseline conditions. Estimated short-term herbaceous forage production would decline to approximately 16,800 tons (a decrease of 2,200 tons or 12%) and long-term production to 16,600 tons (a decrease of 2,400 tons or 13%) compared to baseline conditions. These declines would be due to the restoration of cultivated fields to less productive native vegetation.

As compared to Alternative 1, Alternative 2 would have 1,700 fewer tons (7%) of total forage production in the short term and 500 fewer tons (2%) in the long term. Herbaceous forage production under Alternative 2 would be 2,000 fewer tons (11%) in the short term and 1,900 fewer tons (10%) in the long term.

**Conclusion**

As compared to Alternative 1, total forage production on all habitat types under Alternative 2 would be less by a minor amount in the short term and by a negligible amount in the long term. Her-
Impacts on Habitat: National Elk Refuge

Alternative 3 (Option A)

Analysis

Under Option A of Alternative 3 the estimated average total forage production for all habitats on the National Elk Refuge (24,250 acres) in the short term would be 23,000 tons (a 100-ton increase or 0.5%) and in the long term 23,500 tons (a 600-ton increase or 3%) as compared to baseline conditions. The increase in total forage production would be due primarily to the natural conversion of native grasslands to sagebrush shrublands and the increase in woody vegetation due to fewer numbers of browsing elk. Estimated short-term herbaceous forage production would decrease to 18,700 tons (a 300-ton decrease or 2%) and long-term production to 18,400 tons (a 600-ton decrease or 3%).

As compared to Alternative 1, Alternative 3 would have a similar amount of total forage production in the short term and an estimated 500 more tons (2%) in the long term. Herbaceous forage production under Alternative 3 would have 100 fewer tons (0.5%) in the short and long terms as compared to Alternative 1.

Conclusion

As compared to Alternative 1, total forage production under Alternative 3, Option A, would be more by a negligible amount in the short and long terms. Herbaceous forage production would be less by a negligible amount.

Alternative 3 (Option B)

Analysis

Under Option B of Alternative 3 the estimated average total forage production for all habitats on the National Elk Refuge (24,250 acres) would be estimated at 21,500 tons in the short term (a 1,400-ton decrease or 6%) and 22,400 tons in the long term (a 500-ton decrease or 2%) compared to baseline conditions. Estimated herbaceous forage production would decrease to 16,900 tons in the short term (a 2,100-ton decrease or 11%) and 16,700 tons in the long term (a 2,300-ton decrease or 12%). These declines would be due to restoring cultivated fields to less productive native vegetation.

Compared to Alternative 1, total forage production under Option B would decrease by 1,500 tons (7%) in the short term and 200 tons (1%) in the long term. Herbaceous forage production would decrease by 1,900 tons (10%) in the short term and 1,800 tons (9%) in the long term.

Conclusion

As compared to Alternative 1, total forage production under Option B of Alternative 3 would be less by a minor amount in the short term and a negligible amount in the long term. Herbaceous forage production would be less by a minor amount in the short and long terms.

Alternatives 4 and 5

Analysis

Under Alternatives 4 and 5 a 500-acre willow exclosure, a 100-acre cottonwood exclosure, and a 1,000-acre aspen exclosure would be erected to allow woody vegetation to recover from ungulate browsing. The forage in these exclosures would not be available for elk and bison, but would provide habitat for Neotropical migratory birds. Under Alternative 5 average total forage production for all vegetation types on 22,650 acres outside the exclosures would be an estimated 21,100 tons in the short and long terms. This is an estimated 1,800 tons (8%) less than under baseline conditions. Herbaceous forage production would decrease by an estimated 1,600 tons (8%) in the short term and by 1,800 tons (9%) in the long term as compared to baseline conditions.

Sprinkler irrigation on 1,100 acres would increase forage production on cultivated fields. However, fencing off willow, cottonwood, and aspen habitat would withdraw 1,600 acres from the refuge’s forage production base. The result would be a minor decrease in overall total and herbaceous forage available for elk and bison.

As compared to Alternative 1, total forage production under Alternatives 4 and 5 would be less by 1,900 tons (8%) in the short term and 1,500 tons (7%) in the long term. Herbaceous forage produc-
tion would be less by 1,400 tons (7%) in the short term and 1,300 tons (7%) in the long term.

Conclusion
As compared to Alternative 1, total forage production and herbaceous forage production under Alternatives 4 and 5 would be less by a minor amount in the short and long terms.

Alternative 6
Analysis
Under Alternative 6 a total of 600 acres of aspen stands would be enclosed within several temporary rotating exclosures, and a 100-acre cottonwood permanent exclosure would be erected to allow woody vegetation to recover from over-browsing by ungulates. These exclosures would be unavailable for elk and bison, but they would provide habitat for Neotropical migratory birds. However, 600 acres of forage within these exclosures would become available for ungulates after approximately 30 years, unless it was evident that temporary, rotating exclosures must continue indefinitely to preserve aspen habitat on the refuge.

Under this alternative the estimated short-term total forage production for all habitats on the refuge outside the exclosures would be 22,600 tons (on 23,550 acres), a 300-ton (or 1%) decrease from baseline conditions. Estimated long-term production would be 24,200 tons (on 24,150 acres), a 1,300-ton (6%) decrease. Herbaceous forage production would be 400 tons (2%) less in the short term and 100 tons (0.5%) more in the long term than under baseline conditions.

Sprinkler irrigation on 1,100 acres would increase forage production on cultivated fields, and fewer elk would allow willow habitat to recover. The result would be a negligible to minor increase in overall total and herbaceous forage in the short term and a minor increase in the long term.

As compared to Alternative 1, total forage production under Alternative 6 would be less by 400 tons (2%) in the short term and more by 1,600 tons (7%) in the long term. Herbaceous forage production would be less by 200 tons (1%) in the short term and more by 600 tons (3%) in the long term.

Conclusion
Total forage production under Alternative 6 would be less by a negligible amount in the short term and more by a minor amount in the long term compared to Alternative 1. Herbaceous forage production would be less by a negligible amount in the short term and more by a negligible amount in the long term.

GRAND TETON NATIONAL PARK

Sixty-three plant community types identified in Grand Teton National Park and John D. Rockefeller, Jr., Memorial Parkway were divided into nine general categories (excluding open water and human development), as described in Chapter 3.

Marshlands
Impacts of All Alternatives
Analysis
The marshland communities in Grand Teton National Park are expected to experience negligible changes in acreage or condition in the short and long terms under all alternatives compared to baseline conditions (see Table 4-4).

Conclusion
The acreage of marshland habitat in the national park would not be expected to change more than a negligible amount under any alternative. None of the alternatives would result in the impairment of marshland habitat.

Mitigation
Mitigation for park marshlands would not be necessary.

Wet Meadows
Alternative 1
Analysis
A study by McCloskey and Weidner (2002) in three wet meadow sites may indicate that heavy ungulate use is negatively affecting plant reproductive capacity, flowering height, canopy cover, and percentage of bare ground in some wet meadow habitats. Kentucky bluegrass (a nonna-
**TABLE 4-4: SUMMARY OF POTENTIAL CHANGES IN ACRES OF HABITATS RELATIVE TO BASELINE ACREAGES — GRAND TETON NATIONAL PARK**

<table>
<thead>
<tr>
<th>Vegetation Category</th>
<th>Baseline</th>
<th>Alternative 1</th>
<th>Alternative 2</th>
<th>Alternative 3</th>
<th>Alternative 4</th>
<th>Alternative 5</th>
<th>Alternative 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marshlands</td>
<td>16,968</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
</tr>
<tr>
<td>Wet Meadows</td>
<td>13,390</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
</tr>
<tr>
<td>Native Grasslands</td>
<td>8,093</td>
<td>NC</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Sagebrush Shrubslands</td>
<td>56,843</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Riparian and Aspen Woodlands</td>
<td>22,234</td>
<td>–</td>
<td>+</td>
<td>+</td>
<td>NC+</td>
<td>NC+</td>
<td>+</td>
</tr>
<tr>
<td>Conifer Forest</td>
<td>123,093</td>
<td>+</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
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<tr>
<td>Agricultural Lands</td>
<td>5,610</td>
<td>NC</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Bare Rock and Krummholz</td>
<td>58,640</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
</tr>
<tr>
<td>Tundra</td>
<td>5,635</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
</tr>
</tbody>
</table>

NC = no change from baseline numbers of acres.  
+ = an increase in acres of this plant community type.  
– = a decrease in acres of this plant community type.

tive grass species) and oxeye daisy (a nonnative invasive weed) occur in wet meadow habitats and are preferred forage for elk and other ungulates. They have low growing points and can spread by sending out stems that creep along the surface or under the surface of the soil and do not need to make seed to reproduce. Kentucky bluegrass and oxeye daisy can be grazed to the ground and thrive and expand. Heavy grazing pressure on the edges of these meadows appears to be allowing both of these nonnatives to outcompete native grasses and expand their range. Approximately 80% of these meadows are currently in nonnative plant species (Haynes, pers. comm. 2004). The spread of nonnative species can occur fairly rapidly, and continued heavy grazing and ground disturbance would likely result in an increase in exotic species in wet meadow communities (Hobbs and Huenneke 1992; Singer 1995).

Wet meadow acreage under Alternative 1 would not change due to any management actions that are being considered in this planning process. However, wet meadow plant communities might shift from native species to nonnative species in some areas as large numbers of elk and growing numbers of bison continued to heavily graze in these areas. This effect might be more pronounced on the west side of the Snake River due to the fact that it serves as a safe zone from hunting.

**Conclusion**

There would be no change in the amount of wet meadow acreage in the national park, but there could be a shift from native species to nonnative species in some areas due to grazing pressure by elk and bison. Alternative 1 would not result in the impairment of wet meadow habitat in the park.

**Alternative 2**

**Analysis**

Fewer elk and bison summering in the national park in most years would result in fewer areas of bare ground in wet meadow habitats and less invasion by nonnative plant species. In the short and long terms, wet meadow acreage would not change due to any management actions under this alternative compared to baseline conditions and Alternative 1. Conversely, in years when elk numbers ranged from 2,000 to 3,000 in the park, nonnative plant species could expand their range in the wet meadow communities due to heavy elk grazing (Haynes, pers. comm. 2003).

**Conclusion**

In the short and long terms wet meadow acreage would not change due to any management actions under this alternative compared to baseline conditions and Alternative 1. Alternative 2 would not result in the impairment of wet meadow habitat.

**Alternatives 3, 4, and 6**

**Analysis**

Fewer numbers of ungulates summering in the national park could result in fewer areas of bare ground in wet meadow habitats and fewer invasions by nonnative plant species. Large numbers of bison under Alternative 3 could negate some benefits to wet meadow communities in areas where bison graze. Wet meadow acreage would
not change under these alternatives, and wet meadow plant communities would likely remain dominated by native plant species due to fewer numbers of elk grazing in the park, especially under Alternative 6.

**Conclusion**

Fewer ungulates summering in the national park could result in less bare ground in wet meadow habitats and fewer invasions by exotic species. Large numbers of bison under Alternative 3 could negate some benefits to wet meadow communities in areas where bison graze. Most wet meadow acreage would not change under these alternatives. Alternatives 3, 4, and 6 would not result in the impairment of wet meadow habitat in the park.

**Alternative 5**

**Analysis**

Fewer bison summering in the national park could result in fewer areas of bare ground in wet meadow habitats and fewer invasions by nonnative plant species; however, positive effects would be less than under Alternatives 2, 3, and 4 because the number of elk under Alternative 5 would be similar to those under Alternative 1. Wet meadow acreage would not change, but wet meadow plant communities in some areas of the park would likely shift from native species to nonnative species due to more than 2,000 elk grazing in the park (Haynes, pers. comm. 2003). This effect might be more pronounced on the west side of the Snake River because it serves as a safe zone from the elk herd reduction program.

**Conclusion**

The positive effects would be less than under Alternatives 2, 3, and 4 because the number of elk under Alternative 5 would be similar to those under Alternative 1. Wet meadow acreage would not change, but wet meadow plant communities in many areas of the park would likely shift from native species to nonnative species because there would be more than 2,000 elk grazing in the park. Alternative 5 would not result in the impairment of wet meadow habitat.

**Mitigation**

No mitigation beyond measures to reduce numbers of elk and bison, as considered in the alternatives, would be necessary.

**Native Grasslands**

**Alternative 1**

**Analysis**

Baseline numbers of elk and bison under Alternative 1 are not expected to affect acreage or condition of native grassland communities in the short or long terms compared to baseline conditions. However, if bison numbers continued to increase under Alternative 1 (potentially up to 2,000–3,000), heavily grazed areas would increase, resulting in more bare ground and shorter, less dense vegetation in many areas. As the condition of native grassland habitats declined with increasing grazing pressure, nonnative plant species could invade and possibly dominate many areas (Haynes, pers. comm. 2004). A future reduction in bison numbers could correct the problem.

**Conclusion**

In the short term current numbers of elk and bison are not expected to affect the condition of native grassland communities in the national park to any measurable degree. In the long term increasing numbers of bison could cause the condition of native grassland habitat to decline in some areas. However, the limited extent of impacts would not result in the impairment of native grassland habitat in the park.

**Alternatives 2–6**

**Analysis**

Approximately 4,500 acres of agricultural lands would be restored to native plant communities. At present it is not possible to quantify gains in native grasslands and sagebrush shrublands as a result of this restoration. Actual acreage increases would depend on soils, grazing pressure, slope, aspect, availability of prescribed fire, proximity to native vegetation communities, and available surface and subsurface moisture. For the sake of this analysis it is assumed that native grassland and
sagebrush shrubland habitats would gain in the long term, with 2,250 acres of each habitat type.

Restoring agricultural lands would initially increase native grassland communities by about 4,500 acres. In the long term (longer than 25 years), approximately 2,250 acres of native grassland habitat would convert to sagebrush shrubland communities. This would bring the long-term total for native grassland habitats to an estimated 10,340 acres.

Lower numbers of elk and bison under this alternative would contribute to a minor increase in species diversity and probably result in less open ground as observed by Zeigenfuss et al. (2003) in areas currently receiving intense grazing.

**Conclusion**

Native grassland habitat in the park would increase by an estimated 4,500 acres under Alternative 2 in the short term, which is similar to Alternatives 3–6. In the long term it is estimated that sagebrush would dominate about half of this acreage, leaving approximately 2,250 acres more native grassland habitat compared to Alternative 1. The condition of native grassland habitat could improve negligibly in some areas due to fewer bison. Native grassland habitat would not be impaired in the park under this alternative.

**Mitigation**

The reestablishment of native vegetation on formerly cultivated areas in the park without a follow-up program to periodically burn sagebrush shrubland habitat would result in a high amount of sagebrush habitat and low production of herbaceous vegetation in sagebrush communities. Periodic prescribed fire over the long term in restored vegetation communities would mitigate this adverse effect.

**SAGEBRUSH SHRUBLANDS**

**Alternative 1**

**Analysis**

Sagebrush shrubland habitat in the national park covers approximately 56,840 acres, and a high amount is in an advanced stage of succession. Under Alternative 1 sagebrush shrubland communities could increase in acreage as mature aspen stands converted to sagebrush shrubland habitats due to heavy elk browsing, climate change, and fire suppression. Localized areas could also decline in condition due to the large numbers of bison allowed in this alternative.

**Conclusion**

Under Alternative 1 sagebrush shrubland communities in the national park might increase in acreage in the short term compared to baseline conditions. In the long term sagebrush shrubland habitat could increase due to conversion of aspen stands. Localized areas could also decline in condition due to the growing bison population, but the limited extent of impacts would not result in the impairment of sagebrush shrubland habitat in the park.

**Alternatives 2–6**

**Analysis**

Under Alternatives 2–6 sagebrush shrubland communities would not be expected to change in condition or acreage in the short term from baseline conditions. Compared to Alternative 1, sagebrush shrubland condition and acreage in these alternatives would be similar in the short term, and acreage would be greater by 2,250 acres in the long term.

Fewer elk and bison grazing in the national park would contribute to a minor potential increase in species diversity and would likely result in less open ground as observed by Zeigenfuss et al. (2003a) in areas that are currently intensely grazed.

**Conclusion**

In the long term it is estimated that the amount of sagebrush shrubland habitat in the park would increase by approximately 2,250 acres, as some restored native grassland habitat succeeded to sagebrush shrubland communities. The condition of sagebrush shrubland habitat could improve negligibly in some areas due to fewer bison. Sagebrush shrubland habitat would not be impaired under these alternatives because there would be a net increase in the amount of sagebrush habitat.
(in what are now agricultural fields), and elk and bison numbers would not be higher than the habitat can support.

Mitigation

Mitigation measures for potential adverse impacts to sagebrush shrubland habitats in the Jackson Hole area would be similar to those discussed under “Native Grasslands” above.

Riparian and Aspen Woodlands

Alternative 1

Analysis

Riparian and aspen woodland communities presently occur on approximately 22,320 acres in Grand Teton National Park and are composed of willow, aspen, and cottonwood habitats.

Aspen Communities

Currently, 51% of surveyed stands in the park are considered to be healthy, functioning normally, and regenerating in the absence of disturbance (McCloskey and Sexton 2002). Recently disturbed stands (9% of surveyed stands) are also healthy and regenerating but have experienced sharp declines in the number of suckers three years after a fire, and they could be negatively affected by ungulate browsing. More monitoring is necessary to determine the success of suckers under current site conditions.

An estimated 40% of aspen communities (mature and encroached stands) are in the process of converting to other habitat types (McCloskey and Sexton 2002). Mature aspen stands (22% of the surveyed stands) are being negatively affected by a combination of climate change, suppressed fire, and ungulate browsing. Intense browsing by an estimated 2,500–3,200 elk under Alternative 1 would most likely continue to adversely affect these mature stands.

Conifer-encroached aspen stands (particularly those that are heavily browsed) are in the process of converting to conifer forests. Unlike solid stands of aspen, conifer-encroached aspen stands carry fire well. In nature, conifer encroachment is a necessary prerequisite for an aspen stand-replacing fire.

Given the numbers of elk under Alternative 1 and the effects described above, aspen acreage would likely begin to decrease compared to baseline conditions due to the relatively high level of browsing pressure in the park and the encroachment of conifer trees. Over the long term (greater than 50 years) aspen could potentially diminish by as much as 50% across the landscape under existing trends (McCloskey and Sexton 2002).

Willow Communities

Most willow stands are in good to excellent condition (Singer and Zeigenfuss 2003). Of the willow stands found to be heavily browsed in the park, the majority were in areas having high or very high moose densities (Singer and Zeigenfuss 2003). Currently, elk only minimally contribute to heavy browsing of willow in the park, impacting localized areas only. In areas where willow has been burned, ungulate browsing has kept regrowth within the browse zone.

Cottonwood Communities

In general, cottonwood stands in the park are in poor condition, with some stands in a low-fair condition (Haynes, pers. comm. 2003). Lack of flooding, current numbers of elk, and growing numbers of bison could be expected to continue to degrade cottonwood habitat in the short and long terms until it disappears from the landscape in the national park.

Many cottonwood stands are mature, and if current conditions continued under Alternative 1, these stands could disappear over the next 50–100 years (Haynes, pers. comm., 2003).

Ungulate browsing, rubbing, and trampling, although not as severe as on the refuge, contribute to the decline in condition of some cottonwood stands in the park.

Conclusion

Elk numbers in Grand Teton National Park under Alternative 1 would likely continue to contribute to declining conditions and acreage of aspen habitat due to the relatively high levels of browsing.
Although elk could be adversely affecting willow stands in areas, the effects appear to be localized and relatively small. Cottonwood stands are being affected by ungulate browsing, rubbing, and trampling. Browsing by elk in this alternative would not impair woody vegetation habitat because it is only one of several factors that are having negative impacts on riparian and aspen woodland communities.

**Alternative 2**

**Analysis**

Alternative 2 has no objective for elk numbers, but an estimated 600–3,000 elk could summer in Grand Teton National Park under this alternative. In years when elk numbers were at the lower end of the estimate, this would represent a decrease of approximately 75% compared to current low years. In years when elk numbers were at the upper end, this would be similar to recent high numbers.

**Aspen Communities**

Under Alternative 2 the intensity of browsing in aspen stands would decline somewhat as a result of reduced numbers of elk in the Grand Teton segment, which would permit more aspen recruitment. Successive waves of good recruitment years would be essential to maintaining healthy and self-perpetuating stands over the long term.

Although the number of elk in the Grand Teton segment would decline under this alternative, use of aspen stands in the park by elk from the Yellowstone and Teton Wilderness segments would continue and could increase with the eventual elimination of winter supplemental feeding on the refuge and the cessation of the elk herd reduction program in the park. The number of wintering elk in the park could be higher than baseline conditions and Alternative 1. Aspen communities currently in the mature category and those threatened with encroachment (40% of the total) would benefit most from reductions in the Grand Teton herd segment (McCloskey and Sexton 2002). However, other aspen communities, especially those in which aspen is no longer a dominant species, would also benefit, especially if some type of disturbance, such as fire, was reintroduced.

Compared to baseline conditions and Alternative 1, Alternative 2 would likely result in a minor amount of additional aspen habitat in the long term, especially in stands that currently are classified as mature (Haynes, pers. comm. 2003).

**Willow Communities**

The condition of a small proportion of the willow communities in the national park that are currently heavily browsed could improve in localized areas, resulting in taller willow stems and possibly increased density of willow plants in these areas. If the amount of willow habitat increased under Alternative 2, it would only increase by a minor amount, and this additional willow habitat would likely occur in small spring and seep areas (Haynes, pers. comm. 2003).

**Cottonwood Communities**

Large fluctuations in summering elk numbers down to an estimated 600 (almost 25% of existing numbers) would provide low-browsing pressure years, with a probable surge in cottonwood recruitment, assuming conducive environmental conditions. Cottonwood recruitment along the Snake River would likely occur only if the flood regime was restored (Haynes, pers. comm. 2003).

Compared to baseline conditions and Alternative 1, Alternative 2 would likely result in more cottonwood habitat in the short and long terms. This would occur on tributary streams to the Snake River where normal flooding still takes place.

**Conclusion**

Overall browsing pressure by elk in the park would decline substantially, and there would likely be consecutive years of low elk numbers, which would allow recovery of some heavily browsed stands (possibly as low as 600 elk compared to a baseline low of an estimated 2,500). Compared to Alternative 1, willow, cottonwood, and aspen acreage would likely be higher by a negligible to minor amount, with a minor increase in plant species diversity occurring within aspen, willow, and cottonwood communities. Alternative 2 would not impair these habitats because elk are currently not impairing woody vegetation in the park, and lower elk numbers would benefit these communities.
Alternative 3

Analysis
An estimated 500–1,000 elk would summer in Grand Teton National Park under Alternative 3, a reduction of an estimated 70%–80% compared to baseline conditions.

Aspen Communities
The effects of Alternative 3 would be similar to those of Alternative 2. Additionally, compared to baseline conditions and Alternative 1, Alternative 3 would result in improved conditions and a minor amount of additional aspen habitat in the short and long terms.

Willow Communities
A small proportion of the willow communities in Grand Teton National Park that are currently heavily browsed could receive less browsing pressure in localized areas (moose currently exert more browsing pressure on willows in the park than do elk). Compared to baseline conditions and Alternative 1, Alternative 3 could result in improved condition of willow stands and possibly a minor increase in the amount of willow habitat in the long term. This additional willow habitat would likely occur in spring and seep areas (Haynes, pers. comm. 2003).

Cottonwood Communities
A reduction in elk numbers would allow more cottonwood trees to regenerate in those areas where flooding occurs and cottonwood saplings to grow out of the browse zone. Other deciduous woody understory vegetation would also be allowed to recover in some areas (Haynes, pers. comm. 2003). Under this alternative bison could still occasionally rub or girdle large trees, but the effect would not be great enough to reduce the recovery of most cottonwood stands. In areas where flooding rarely occurs, cottonwood habitat would continue to decline. Compared to baseline conditions and Alternative 1, the effects of Alternative 3 would result in an improved condition of many cottonwood stands.

Conclusion
Browsing pressure by elk would decline substantially under Alternative 3 due to an estimated 70%–80% reduction in elk numbers in the park. This reduction in browsing pressure could result in a minor improvement in the condition and acreage of willow, cottonwood, and aspen communities in the long term compared to Alternative 1. The beneficial effects would only be minor because willow communities would continue to be affected by moose browsing, cottonwood habitat would continue to be affected by reduced flooding along the Snake River, and aspen habitat would continue to be affected by the lack of disturbance and conifer encroachment. These habitats would not be impaired under Alternative 3 because elk are currently not impairing woody vegetation in the park, and substantially lower elk numbers would benefit woody vegetation communities.

Alternative 4

Analysis
Approximately 1,600 elk would summer in Grand Teton National Park under Alternative 4; this would be an estimated 50% decline from baseline conditions, which would result in a moderate to major reduction in browsing pressure.

Aspen Communities
A moderate to major reduction in the number of elk in the Grand Teton herd unit would contribute to lower levels of browsing in aspen stands at some times of the year, which would allow larger numbers of aspen suckers to grow taller than 10 feet. These benefits would be offset somewhat by a potential increase in the use of aspen stands by migrating and wintering elk from the Yellowstone and Teton Wilderness segments due to cutbacks in winter supplemental feeding on the refuge and no declines (and possible increases) in elk numbers in these other segments. Compared to baseline conditions and Alternative 1, the effects of Alternative 4 would result in aspen communities that are in better condition and could result in a minor addition of aspen acreage in the long term (Haynes, pers. comm. 2003).
**Willow Communities**

A small proportion of willow communities in the national park that are currently heavily browsed might receive less browsing pressure in localized areas, resulting in taller willow stems and possibly increased density of willow plants in these areas (Haynes, pers. comm. 2003). Compared to baseline conditions and Alternative 1, Alternative 4 could improve conditions of willow stands and increase the amount of willow habitat, but by no more than a negligible amount in the long term. The numbers of elk would be large enough in this alternative that some elk would still likely gravitate to the spring and seep areas where any additional willow cover would be likely.

**Cottonwood Communities**

Browsing intensity in cottonwood stands would also decline by a moderate to major extent compared to baseline conditions and Alternative 1. This decreased browsing intensity would allow more cottonwood saplings to grow beyond the browse zone than would occur under Alternative 1 and to eventually achieve tree size. The flood regime would continue to be the limiting factor in cottonwood stand regeneration. Compared to baseline conditions and Alternative 1, the effects of Alternative 4 would result in a minor improvement in the condition of cottonwood communities in the long term (Haynes, pers. comm. 2004).

**Conclusion**

Browsing pressure by elk would decline somewhat under Alternative 4 due to an estimated 50% reduction in elk numbers in the park, which could result in a minor improvement in the condition and acreage of aspen communities in the long term compared to Alternative 1. Fewer elk would also benefit willow and cottonwood communities but not to the same extent as aspen stands because elk are having less of an effect on willow and cottonwood communities. Alternative 4 would not impair these habitats because elk are currently not impairing woody vegetation in the park, and lower elk numbers would benefit woody vegetation communities.

**Alternative 5**

**Analysis**

The number of elk summering in the national park under Alternative 5 would remain below 2,500 animals after initial reductions. Browsing intensity could decrease by a negligible amount compared to baseline conditions. There might be negligible benefits to aspen, willow, and cottonwood habitats in the short and long terms compared to baseline conditions and Alternative 1 because of reduced browsing pressure. Aspen habitat would continue to be affected by the lack of disturbance and conifer encroachment. Cottonwood habitat would continue to be affected by reduced flooding along the Snake River.

**Conclusion**

Elk browsing pressure in the park could decline by a negligible amount under Alternative 5 due to a negligible to minor reduction in elk numbers. This reduction in browsing pressure could result in a negligible improvement in condition and acreage of aspen communities in the long term compared to Alternative 1. Lower elk numbers could also benefit willow and cottonwood communities, but not to the same extent as aspen stands because elk are having less of an effect on willows and cottonwoods. This alternative would not impair these habitats because elk are currently not impairing woody vegetation in the park, and slightly lower elk numbers would not increase adverse impacts to woody vegetation communities.

**Alternative 6**

**Analysis**

The effects of Alternative 6 on aspen, willow, and cottonwood communities in the national park would be similar to the effects of Alternative 4, except that (1) the lack of winter supplemental feeding on the refuge could result in more elk wintering in the park, and (2) the periodic major reductions in elk numbers in the park under Alternative 6 (following above-average and severe winters) would provide periods of enhanced recovery. An estimated 1,200–1,600 elk would summer in Grand Teton National Park under Alternative 6, which is an estimated 50% decline from baseline conditions. This reduction in elk numbers could
greatly reduce browsing pressure compared to baseline conditions and Alternative 1, recognizing that use of the national park by elk from the Yellowstone and Teton Wilderness herd segments might increase slightly in some years.

**Conclusion**

Browsing pressure by elk would decline under Alternative 6 due to an estimated 50% reduction in elk numbers in the park. This reduction would result in effects that are similar to those described in Alternative 4. Alternative 6 would not result in the impairment of riparian and aspen woodland habitats.

**CONIFER FORESTS**

**All Alternatives**

**Analysis**

Currently, conifer-encroached aspen stands are converting to conifer forest due to heavy browsing of aspen by elk and fire suppression, and this would not change under Alternative 1. In the long term conifer forest habitat could become the dominant plant community in many areas that are currently aspen woodland habitats. Conifer forest habitats are also encroaching on cottonwood communities along the Snake River due to the elimination of flooding after completion of Jackson Dam. In the long term conifer forest communities could increase in acreage as they became the dominant plant community along the Snake River.

Alternatives 2–6 would not affect conifer forests, conifer-encroached aspen stands, or conifer-encroached cottonwood forests more than a negligible amount in the park.

**Conclusion**

Conifer forest communities in the park might experience a negligible increase in acreage under Alternative 1 due to minor increases in conifer cover in aspen stands. Alternatives 2–6 would not affect conifer forests, conifer-encroached aspen stands, or conifer-encroached cottonwood forests more than a negligible amount. Conifer forests in the park would not be impaired under any of the alternatives.

**Mitigation**

No mitigation would be necessary.

**AGRICULTURAL LANDS**

**Alternative 1**

**Analysis**

Agricultural lands include approximately 5,610 acres of historically cultivated lands in the Elk Ranch area in the northern part of Grand Teton National Park and the Kelly hayfields, Mormon Row, and Hunter-Talbot areas in the southern part of the park. It is anticipated that the acreage of agricultural lands would not change under Alternative 1.

Under Alternative 1 irrigation on Elk Ranch and the weed control program would continue, with some experimental restoration of agricultural lands to native habitats in limited areas. Irrigation on an estimated 1,100 acres at Elk Ranch could continue only as long as those pastures are needed for livestock grazing. Following cessation of livestock grazing, irrigation would be continued while restoration was planned and implemented to reduce the threat of invasions by nonnative plant species, which has happened in areas such as the Kelly hayfields and Hunter Ranch. Otherwise, agricultural lands are expected to remain similar to baseline conditions because continued irrigation on Elk Ranch and only experimental agricultural restoration would not significantly alter agricultural plant communities over the short or long term.

Should populations of bison continue to grow unchecked under Alternative 1, competition for preferred grazing sites, mostly in agricultural areas and native grassland sites, would increase, with some localized damage becoming evident. Hobbs et al. (2003) noted that some areas regardless of population size would always be excessively used. This excessive use would most likely continue to affect agricultural lands and increase with increasing numbers of bison, but the overall effect across the park would not be significant.

More bison would mean more disturbance from wallowing. Staff at the national park have noticed some evidence of wallows serving as a point of establishment for nonnative invasive plant spe-
cies, but managers have not documented this effect (Haynes, pers. comm. 2003).

**Conclusion**

Acreage and forage production on agricultural lands in Grand Teton National Park would remain similar to baseline conditions in the short and long terms. Allowing nonnative invasive plant species to remain on agricultural lands would not impair park resources.

**Alternatives 2–6**

**Analysis**

Approximately 4,500 acres of nonnative plant communities on agricultural lands in the Kelly hayfields, Mormor Row, and Hunter-Talbot areas would be restored to native vegetation communities. Agricultural lands would gradually decrease from approximately 5,600 to approximately 1,100 acres over an estimated 20–30 years or more.

About 1,100 acres of agricultural lands in the Elk Ranch area would not be restored to native vegetation and would continue to be irrigated as long as livestock are grazed in this area. Agricultural lands are primarily at the lower elevations of the park; therefore, most treated lands would likely be restored to native grasslands and sagebrush shrubland communities. Depending on moisture availability, some negligible amounts of acreage could revert to riparian and aspen woodland habitats and possibly marshland communities (Schiller, pers. comm. 2002). For the purposes of this analysis, native grassland communities and sagebrush shrubland habitats are each assumed to gain 50% of the 4,500 acres that would be restored. Plant species diversity would be expected to increase substantially on these restored agricultural lands.

Native grasses would likely far surpass nonnative plant species in palatability, and these restored agricultural lands could provide relief to ranges on the refuge in both spring and fall.

Competition for preferred grazing sites, mostly in agricultural and native grassland sites, would continue to cause some localized damage.

**Conclusion**

In the park there would be 4,500 fewer acres of agricultural land in the long term. Plant species diversity would increase substantially on these lands. Park resources would not be impaired because native vegetation would be restored and the potential effects of restoration activities would be minor and of short duration.

**Mitigation**

No mitigation would be necessary.

**BRIDGER-TETON NATIONAL FOREST**

**Marshlands**

Marshland habitats in the national forest would not be affected in the short or long term by Alternatives 2 through 6 any differently than they are being affected under Alternative 1.

**Wet Meadows**

**Alternatives 1 and 5**

The condition of wet meadow habitat varies widely in the Teton Division, from good condition to fair or poor condition (USFS 2003b). Most wet meadow habitats likely do not receive heavy use by elk, but heavy use does occur in some areas especially near state feedgrounds. Small wet meadows that exist as openings in conifer forests are typically in good ecological condition (USFS 2003b). In general, the acreage of wet meadow habitat is decreasing due to succession and fire suppression, resulting in encroachment by sagebrush and conifer trees.

Wet meadow habitats in the national forest would not be affected because elk and bison would be fed on the refuge in most or all years. Wet meadows would continue to be heavily grazed in localized areas, and light grazing would occur in most areas.

**Alternatives 2, 3, 4, and 6**

In the short term few if any changes in the condition of wet meadow habitat in the national forest would be observed because elk would continue to be fed alfalfa pellets in above-average winters. In
the long term, as supplemental feeding was phased out, more elk would remain in the national forest. This could lead to a higher level of grazing pressure in some riparian wet meadow communities in the long term compared to baseline conditions and Alternative 1.

If large numbers of elk migrated to the Green River basin and the Red Desert under Alternatives 2, 3, and 6, some wet meadow communities in the Pinedale and Big Piney ranger districts could receive higher levels of grazing by elk. Residual vegetation could be reduced in areas; however, to the extent this happened, it would occur during transition periods when elk were on the move.

**Native Grasslands**

**Alternatives 1 and 5**

Native winter range in the Gros Ventre River, Spread Creek, and Buffalo Valley drainages would not be affected any more under these alternatives in the short and long terms than under baseline conditions. Supplementally feeding elk every winter on the National Elk Refuge, in combination with winter feeding on the three state feedgrounds in the Gros Ventre River drainage, would continue to draw elk away from native winter ranges, thereby reducing any widespread adverse impacts caused by large numbers of wintering elk. However, adverse impacts to grassland habitat would continue within and adjacent to state feedgrounds and along major elk migration routes to these sites, with the severity of impacts varying from site to site (Kilpatrick, pers. comm. 2004). Ecological conditions in areas designated as southern slope mosaic, which includes grassland and sagebrush habitat, would continue to be within potential functioning condition. Forage production would continue to be limited in sagebrush communities due to excessive shrub cover, and grass production would continue to decline in some areas due to continued increase in the cover of conifer trees. In other words, the carrying capacity of elk winter range in the Buffalo Valley area, the Gros Ventre River drainage, and slopes to the east of the refuge and park would continue to be below natural potential.

Elk and bison that migrate to the refuge would continue to make heavy use of the west and south slopes immediately east of the refuge (e.g., within about 5 miles), which could adversely impact vegetation. This area currently receives use by bison during the late summer and fall, despite bison hunting that occurs on these lands. Larger numbers of bison under Alternative 1 could increase the level of adverse impacts on adjacent national forest lands, although hunting pressure could somewhat reduce impacts.

**Alternatives 2, 3, 4, and 6**

In the short term few if any changes in the condition of winter range in the national forest would be observed because elk would still be fed alfalfa pellets in above-average winters. In the long term larger numbers of elk would make greater use of native winter ranges in the national forest such as in the Buffalo Valley area, the Gros Ventre River drainage, and possibly the south and southwest slopes south of the Snow King Resort (and east of U.S. 191) and the lower Hoback River drainage. However, numbers would not be expected to reach levels that would result in adverse impacts to grassland habitats. During supplemental feeding years in Alternatives 3 and 4 elk would not use native winter range extensively, because feeding would draw them to the refuge.

Habitat improvement projects over the next 15 years in certain areas now dominated by Douglas-fir, mixed conifers, lodgepole pine, and sagebrush would result in an increase in bunchgrass-dominated habitat in areas occupied by elk during winter. These disruptions to vegetation succession would likely more than offset any adverse impacts resulting from an increase in elk use of native winter range by helping disperse elk over larger areas. The increased acreage of native grassland habitat would continue into the long term because treatments would occur on a rotational basis. Heavy use of localized areas by elk during winter and spring under some alternatives could adversely impact vegetation on these sites, but adverse impacts would be lessened by treating relatively large areas. Overall effects on native grassland habitat would be improved to some degree by elk being drawn and hazed onto state feedgrounds, which could result in an increase in adverse impacts to native grassland habitats in the vicinity of the feedgrounds and along major migration routes to these sites (Kilpatrick, pers. comm. 2004).
In the long term bunchgrass-dominated habitat on national forest lands immediately east of the refuge (e.g., within about 5 miles of the refuge) would receive more use by elk and bison. Forage on the west and south slopes immediately to the east of the refuge would remain available longer than forage on much of the southern end of the refuge due to southerly exposures and the fact that slopes enhance the ability of elk and bison to feed on standing forage.

If large numbers of elk began migrating south out of Jackson Hole under Alternatives 2, 3, and 6, and if they were not shortstopped by state feedgrounds, grazing pressure in native grassland habitats in the Pinedale and Big Piney ranger districts could increase. Most of the grazing would occur during migration periods and would therefore not substantially increase grazing pressure. In early spring, elk graze on early green-up as it is available, but spring grazing during the critical growth stage of plants is light because dispersal occurs fairly quickly, and because elk tend to move in small groups rather than large concentrations (BLM 1981). Nonetheless, it is acknowledged that some adverse impacts to grassland habitat could occur in localized areas. Some elk would likely winter in suitable winter range, which could increase the amount of residual grass cover that is removed in some areas. Some localized adverse impacts to vegetation and soils could occur.

**SAGEBRUSH SHRUBLANDS**

**Alternatives 1 and 5**

Native winter range in the Gros Ventre River, Spread Creek, and Buffalo Valley drainages would not be affected any more under this alternative in the short and long terms than has been occurring under baseline conditions. Supplementally feeding elk every winter on the refuge, in combination with winter feeding on the three state feedgrounds in the Gros Ventre River drainage, would continue to draw elk away from native winter ranges, thereby maintaining a relatively low level of adverse impacts caused by large numbers of wintering elk, except adjacent to state feedgrounds. Impacts associated with feedgrounds are greatest within a few hundred yards, but can extend up to a mile depending on topography and other factors. General conditions of the dry forest openings and southern slope mosaic of the Teton Division of the forest, which includes sagebrush habitat, are within potential functioning condition (USFS 2003b). However, carrying capacity of winter range continues to be depressed by (1) more sagebrush habitat than natural (relative to the amount of grassland), (2) lowered forage production in sagebrush communities due to excessive shrub cover, and (3) continued encroachment of coniferous trees into sagebrush habitats. All of these factors are primarily a result of fire suppression.

Although elk typically do not overbrowse sagebrush, they do overutilize green rabbitbrush, antelope bitterbrush, and a variety of herbaceous plant species associated with sagebrush shrubland habitats (Kilpatrick, pers. comm. 2004). One result has been a shift in species composition and reduced plant species diversity and an increase in the density and canopy cover of sagebrush, except on and immediately adjacent to feedgrounds where heavy trampling has greatly reduced sagebrush cover.

Elk and bison that migrate to the refuge would continue to make heavy use of the west and south slopes immediately east of the refuge (e.g., within about 5 miles), which could be adversely impacting sagebrush shrubland habitat. This area currently receives use by bison during the late summer and fall, despite bison hunting on these lands. It is possible that growing numbers of bison in the Jackson herd could increase the level of adverse impacts by bison on adjacent national forest lands, although hunting pressure on these lands could help reduce impacts somewhat.

Under Alternative 5 use of sagebrush shrubland habitat on the west and south slopes would decline in the long term, compared to baseline conditions, and would be even lower compared to Alternative 1.

**Alternatives 2, 3, 4, and 6**

In the short term few if any changes in the condition of winter range in the national forest would be observed because elk would be fed alfalfa pellets in above-average winters. However, in the long term during winters when supplemental forage was not supplied on the refuge, larger numbers of elk would make greater use of native win-
CHAPTER 4. ENVIRONMENTAL CONSEQUENCES

Treatment of sagebrush and other habitats in the Buffalo Valley area and the Gros Ventre River drainage, and slopes immediately to the east of the refuge, would result in an initial reduction of several thousand acres of sagebrush habitat in the Teton Division of the national forest. After the period of initial treatments, sagebrush/grasslands would be rotationally treated about every 25–50 years, which could result in a lower acreage of sagebrush shrubland habitat being maintained than what has occurred in recent years, and sagebrush canopy cover would be lower (Kilpatrick, pers. comm. 2004). If large numbers of elk eventually began migrating to other wintering areas, fewer elk might winter on native winter range in the Gros Ventre River basin than under baseline conditions and Alternative 1, which could alleviate potential adverse impacts.

In the long term bunchgrass-dominated habitat on national forest lands immediately east of the refuge (e.g., within about 5 miles) would receive more use by elk and bison. There would be a moderate to major reduction in elk numbers on the refuge and a major reduction in bison numbers under Alternative 2, but with a major reduction in supplemental feeding within 15 years, there would be an increased use of areas supporting standing forage. Forage on the west and south slopes immediately to the east of the refuge would remain available longer than forage on much of the southern end of the refuge due to southerly exposures and the fact that slopes enhance the ability of elk and bison to feed on standing forage.

If large numbers of elk began migrating south out of Jackson Hole, assuming they were not short-stopped by state feedgrounds, they would likely not have detrimental effects on sagebrush communities in areas used as transitional range. Some areas in the Pinedale and Big Piney ranger districts could be used as winter range by some of these elk.

Bison numbers would be larger under Alternative 3 than under Alternatives 2, 4, and 6, and this could increase adverse effects on sagebrush shrubland communities.

Somewhat lower numbers of elk using native winter range under Alternative 4 would result in fewer adverse impacts than under Alternatives 2 and 3.

RIPARIAN AND ASPEN WOODLANDS

Alternatives 1 and 5

Available information suggests that the current level of browsing in the Gros Ventre River drainage (especially near state feedgrounds) would greatly reduce the amount of aspen habitat in Class I or II condition (see Table 4-2) in the drainage (Krebill 1972a; Bartos, Brown, and Booth 1994). This also assumes continued very low levels of fire in aspen habitat, which is another key factor. There would also be an increase in the low, shrubby growth form of aspen habitat (Kilpatrick, pers. comm. 2004). Some aspen in the Gros Ventre River drainage are in areas not used by elk during critical periods and would remain relatively unaffected.

Alternatives 2, 3, 4, and 6

In the short term browsing by elk would not change appreciably in the national forest because elk would continue to be fed during most winters. As the number of days and annual frequency of winter supplemental feeding declined, more elk would begin using native winter range in the national forest, and this would continue over the long term. Without habitat treatments, larger numbers of elk using winter range in the national forest would increase the already heavy browsing pressure on willow, aspen, and cottonwoods, which could lead to more rapid declines in habitat condition and acreage in some areas.

Despite larger numbers of elk using native winter range under Alternative 2, the treatment of large acreages of conifer-encroached aspen habitat in the Buffalo Valley area and in the upper and lower Gros Ventre River drainage would result in a net improvement in the condition of aspen stands, including more acreage of aspen habitat in Class I or II condition, but only if treatments were conducted in ways that allowed a sufficient number of aspen suckers to grow more than 10 feet tall.
If prescribed fire was used to treat conifer-encroached aspen stands, sagebrush, and other habitats, small acreages of willow and cottonwood habitat could be burned. These small-scale treatments, however, might not offset the adverse impacts of larger numbers of elk wintering in the national forest, and they might actually add to the adverse impacts to willow and cottonwood habitat. Large-scale treatments could increase the quantity and quality of resprouting shrubs and offset the impacts to some willow and cottonwood communities (Kilpatrick, pers. comm. 2004).

**Conifer Forests**

**All Alternatives**

Conifer forests in Bridger-Teton National Forest are not expected to be impacted or would be impacted to a negligible degree by actions being considered in this environmental impact statement.

**Yellowstone National Park**

Approximately 25% of the Jackson elk herd summers in southern Yellowstone National Park south of Yellowstone and Heart lakes, west of the Yellowstone River, and east of the hydrographic divide between two branches of the Snake River. Biologists in Yellowstone National Park concluded that changes in numbers and distribution of elk that would occur as a result of actions taken in this planning process would not measurably affect the habitats in southern Yellowstone. Therefore, effects on habitats are not discussed in this analysis.

**Other Federal and State Lands**

**Marshlands**

Marshland habitats on other federal and state lands would not be affected in the short or long term by Alternatives 2–6 any differently than they are being affected under baseline conditions and Alternative 1.

**Wet Meadows**

**Alternatives 1 and 5**

Wet meadow habitat comprises a small proportion of the lands administered by the Bureau of Land Management in Jackson Hole, and elk would likely have little, if any effect, on these habitats compared to the effects of the Snake River, maintenance of levees, and livestock grazing. On federal and state lands in the Green River basin, minimal use of wet meadow communities by elk would continue.

**Alternatives 2, 3, and 6**

Elk grazing in wet meadow areas along the Snake River could increase by a minor to moderate amount compared to baseline conditions and Alternative 1 due to phasing out supplemental feeding on the refuge.

If large numbers of elk began migrating to the Green River basin and the Red Desert, grazing in riparian wet meadows on lands administered by the Bureau of Land Management could increase, resulting in less residual vegetation. In most areas increased grazing by elk would likely not be high enough to adversely impact these habitats. However, in some localized areas, wet meadow habitat could be grazed heavily enough each year to result in reduced ecological condition due to the already heavy use that some of these areas received from livestock grazing.

**Native Grasslands and Sagebrush Shrublands**

**Alternatives 1, 4, and 5**

Alternatives 1, 4, and 5 would not result in any changes in forage utilization by elk in native grassland and sagebrush shrubland habitats on federal and state lands in the Green River basin and the Red Desert.

**Alternatives 2, 3, and 6**

There would be no additional effects on native grassland and sagebrush shrubland habitats compared to baseline conditions and Alternative 1 if
more elk did not migrate into the Green River basin or the Red Desert to winter or if migrating elk ended up on state feedgrounds.

If substantial numbers of elk from the Jackson elk herd unit began migrating to these areas, and if migrations were not shortstopped by state feedgrounds or cattle feedlines, grazing pressure on native grasslands and sagebrush shrublands would increase in the Green River basin and the Red Desert. Although federal and state lands in the Green River basin could accommodate more elk in some areas (Stroud, pers. comm. 2004), habitats on federal and state lands in their current condition and use levels would not be able to accommodate the numbers of elk that now winter on state feedgrounds in the Green River basin plus some of the elk now wintering on the National Elk Refuge and on state feedgrounds in the Gros Ventre River basin.

Most available forage resources on native grasslands and sagebrush shrublands on federal lands in the Green River basin and the Red Desert are already being consumed by livestock, feral horses, and native ungulates (BLM 1996b; Weymand, pers. comm. 2004). BLM range conservationists attempt to keep total utilization rates by all domestic, feral, and native herbivores lower than approximately half the annual production, although actual standards for specific areas might be somewhat different than 50%.

In addition, a major increase in the number of elk wintering on federal and state lands in the Green River basin and the Red Desert would increase the level of competition with livestock that are in grazing allotments during the winter and early spring. Given the vast acreages involved and unknown numbers and distributions of elk that might migrate to these areas, potential effects cannot be determined beyond this broad assessment at this time.

**Desert Shrublands**

Desert shrubland habitat only occurs in the Green River basin and the Red Desert.

**Alternatives 1, 4, and 5**

These alternatives would not result in any changes in forage utilization by elk in desert shrubland habitats on federal and state lands in the Green River basin and the Red Desert.

**Alternatives 2, 3, and 6**

If more elk did not migrate to the Green River basin to winter, or if migrating elk ended up on state feedgrounds, there would not be any additional effects on desert shrubland habitat compared to baseline conditions and Alternative 1.

If, on the other hand, substantial numbers of elk from the Jackson elk herd unit began migrating to these areas, and if state feedgrounds in the Green River basins were also phased out as part of a large multi-agency effort, grazing pressure in desert shrublands would likely increase in the Green River basin and the Red Desert. Many of the effects would be similar to those described above for sagebrush shrublands under “Other Federal and State Lands.”

**Riparian and Aspen Woodlands**

**Alternatives 1, 4, and 5**

Alternatives 1, 4, and 5 would not result in any changes in the condition of riparian and aspen woodland habitats on federal and state lands in the Green River basin and the Red Desert compared to baseline conditions.

**Alternatives 2, 3, and 6**

Alternatives 2, 3, and 6 would cause few changes in the short term. In the long term, as the number of days and annual frequency of winter supplemental feeding declined on the refuge, browsing pressure could increase in cottonwood habitat along parts of the Snake River, including parcels administered by the Bureau of Land Management. This could further reduce the condition of cottonwood habitats in localized areas.

If large numbers of elk began migrating to the Green River basin and the Red Desert, browsing pressure in willow and aspen habitats on federal and state lands would likely increase. A major increase in elk numbers would further hinder the
recovery of willow habitats and continue the degradation of aspen stands that are already being affected by elk. Furthermore, it is likely that elk would begin contributing to the degradation of willow and aspen habitats in some areas not currently used by elk. In most areas, however, browsing pressure by elk would likely not be high enough to adversely impact these habitats.

**Alternative 4**

Alternative 4 would likely cause few changes in the short term. In the long term, as winter supplemental feeding on the refuge was adaptively reduced, browsing pressure in cottonwood habitat could increase on BLM lands along the Snake River. Conversely, the major reduction in the Grand Teton segment of the elk herd could limit the potential for increased browsing. It is possible that changes under Alternative 4 could contribute negligibly to reductions in the condition of cottonwood habitats on these lands. Alternative 4 would not change the effects that elk are having on cottonwood habitats on BLM areas in the Green River basin and the Red Desert.

**Conifer Forests**

**Alternatives 1, 4, and 5**

Lands administered by the Bureau of Land Management in Jackson Hole do not contain conifer habitat, other than the encroachment of Engelmann spruce and other conifer trees into cottonwood habitat. Over the long term conifer habitat could replace cottonwood habitat in some areas. Conifer habitat on BLM lands in the Green River basin and the Red Desert would not be affected by any of the alternatives.

**Alternatives 2, 3, and 6**

It is not anticipated that the potential increase in elk use of cottonwood habitat on BLM lands in Jackson Hole would measurably increase the rate at which cottonwood habitat would be lost over the long term (e.g., the conversion from cottonwood forests to Engelmann spruce forests). If large numbers of elk began migrating to the Green River basin and the Red Desert, greater browsing pressure could increase the rate at which some aspen forests converted into conifer forests.

**PRIVATE LANDS**

**Marshlands**

Marshland habitats on private lands would not be affected in the short or long term by Alternatives 2 through 6 any differently than they are being affected under Alternative 1.

**Wet Meadows**

**Alternatives 1 and 5**

Because wet meadow habitat on private land is associated with pastureland in many instances, moderate to heavy grazing by livestock is not uncommon; thus, vegetation height in wet meadows is reduced on many private lands. Elk contribute to the grazing pressure on wet meadows during specific times of the year, especially late fall, early winter, and spring. The level of grazing does not compare to that of livestock, but it can measurably affect vegetation height in localized areas. Elk use of wet meadows on private lands in the Green River basin would continue to be minimal.

**Alternatives 2, 3, and 6**

In the short term few changes would be evident in the Jackson Hole area because most elk and bison that would winter on the refuge under Alternative 1 would continue wintering on the refuge under Alternatives 2, 3, and 6. However, after winter supplemental feeding was phased out in the long term, elk and bison could increase their use of wet meadow habitat on private lands in Buffalo Valley, the Gros Ventre River basin, in parts of Jackson Hole, and possibly the Hoback River basin compared to baseline conditions and Alternative 1.

If large numbers of elk started migrating out of Jackson Hole, grazing in riparian wet meadows on private lands could increase, with a reduction in residual vegetation. In most areas increased grazing by elk would likely not be high enough to adversely impact these habitats.

**Alternative 4**

Grazing of wet meadow habitats on private lands in the Jackson Hole area could increase compared to baseline conditions due to reductions in winter.
supplemental feeding on the refuge. Impacts would be reduced if elk and bison were hazed off private lands, except on lands having conservation easements that specifically allow or encourage use by wintering elk or bison.

**Native Grasslands and Sagebrush Shrublands**

**Alternatives 1 and 5**

Alternatives 1 and 5 would not result in any changes in forage use by elk and bison in grassland and sagebrush shrubland habitats on private lands in Jackson Hole, the Buffalo Valley, the Gros Ventre River basin, the Hoback River basin, the Green River basin, or the Red Desert. Elk and bison would continue to have negligible effects on grassland and sagebrush shrubland habitats on private lands.

**Alternatives 2, 3, and 6**

In the short term in Jackson Hole few changes would be evident under Alternatives 2, 3, and 6 because most elk and bison that would winter on the refuge under Alternative 1 would continue wintering on the refuge under these alternatives. In the long term, to the extent that elk and bison found wintering areas outside the refuge after supplemental feeding was reduced, they could increase their use of native grassland and sagebrush shrubland habitats on private lands in Jackson Hole, Buffalo Valley, the Gros Ventre River basin, and possibly the Hoback River basin compared to baseline conditions and Alternative 1. This would reduce forage available to livestock, and forage utilization could be heavy in some areas. However, to the extent that future conservation easements would allow or encourage winter use by elk and/or bison, the extent of the problem could be reduced.

Similarly, if a substantial number of elk began migrating to the Green River basin and the Red Desert, native grassland and sagebrush shrubland habitats on some private lands in these areas could be affected over the long term by increased grazing pressure during fall migration and during winter and early spring, compared to baseline conditions and Alternative 1.

**Alternative 4**

In the short term effects under Alternative 4 would be similar to Alternative 2. In the long term, when a lower proportion of elk were migrating to the refuge for the winter season, elk and bison use of grasslands and sagebrush shrublands could increase on private lands in the Buffalo Valley, parts of Jackson Hole, and the Gros Ventre River basin. This could result in less residual grass cover and sagebrush in localized areas on private lands in Jackson Hole, although no adverse impacts to vegetation conditions or the ability to produce forage would be anticipated.

This alternative would not result in any additional impacts to native grassland habitat on private lands in the Green River basin and the Red Desert.

**Desert Shrublands**

**Alternatives 1, 4, and 5**

These alternatives would not result in any changes in utilization of forage by elk and bison in sagebrush shrubland habitats on private lands in the Green River basin and the Red Desert.

**Alternatives 2, 3, and 6**

The potential effects of a large influx of elk into the Green River basin and the Red Desert would be similar to the potential effects on desert shrubland habitats on federal and state lands in the Green River basin and the Red Desert.

**Riparian and Aspen Woodlands**

**Alternatives 1 and 5**

Currently, the condition and size of willow, aspen, and cottonwood habitat in the Jackson Hole area continue to decline. Browsing of woody riparian vegetation on private lands in the Green River basin is not occurring to any large extent under baseline conditions.

Alternatives 1 and 5 would not change the effects that elk are now having on willow, aspen, and cottonwood habitat on private lands in Buffalo Valley, the Gros Ventre River basin, Jackson Hole, the Hoback River basin, the Green River basin,
and the Red Desert. Elk might be less likely to use private lands under Alternative 5 compared to Alternative 1 due to enhanced forage production on the refuge and less competition with bison, but this at most would have negligible effects.

**Alternatives 2, 3, and 6**

In the short term few changes would be evident in riparian and aspen woodlands in the Jackson Hole area because most elk and bison that would winter on the refuge under Alternative 1 would continue wintering on the refuge under Alternatives 2, 3, and 6. However, to the extent that elk and bison began wintering in areas off the refuge once supplemental feeding was reduced, they could increase their use of private lands. Increased browsing pressure in some areas could be high enough to contribute to further degradation and loss of acreage in willow, aspen, and cottonwood stands.

If large numbers of elk began migrating to the Green River basin and the Red Desert, browsing pressure in some willow, aspen, and cottonwood habitats on private lands could increase, potentially resulting in moderate to major adverse impacts in localized areas.

**Alternative 4**

In the short term in the Jackson Hole area, few changes would be evident because most elk and bison that would winter on the refuge under Alternative 1 would continue wintering on the refuge under Alternative 4. However, to the extent that elk and to a more limited extent bison began wandering out from the refuge onto private lands due to reduced supplemental feeding, use of willow, aspen, and cottonwood habitat could increase on private lands compared to baseline conditions and Alternative 1. Furthermore, if fewer elk migrated to the refuge in fall and winter, use of private lands in Buffalo Valley and the Gros Ventre River basin could increase. Increased damage to woody vegetation could occur in localized areas. Alternative 4 would not change the effects that elk are having on willow, aspen, and cottonwood habitat on private lands in the Green River basin and the Red Desert.

**Conifer Forests**

**Alternatives 1 and 5**

Existing conifer forests on private lands would not be affected under Alternatives 1 and 5.

**Alternatives 2, 3, 4, and 6**

If elk use of aspen habitat increased by a moderate to major amount on particular private lands in the Jackson Hole area and the Green River basin, the rate of loss of aspen habitat and the conversion from aspen habitat to conifer forest could increase. It is not anticipated, however, that greater elk use of cottonwood habitat on private lands in Jackson Hole would increase the rate of loss of cottonwood habitat or the conversion from cottonwood forests to Engelmann spruce forests. Any increases in elk browsing of cottonwood habitat on private lands in the Green River would likely not facilitate a conversion to coniferous forest.

**Agricultural Lands**

**Alternatives 1 and 5**

Elk and bison would continue to have negligible or no effects on private agricultural lands in Jackson Hole, Buffalo Valley, the Gros Ventre River and Hoback River drainages, the Green River basin, or the Red Desert. Supplemental feeding operations on the National Elk Refuge and WGFD elk feedgrounds and hazing activities would continue to keep most elk on feedgrounds and would limit the number of elk venturing onto private lands. In the Green River basin the resident Steamboat elk herd east of Farson primarily inhabits federal lands, and impacts to private agricultural lands are minimal.

**Alternatives 2, 3, and 6**

In the short term effects of elk and bison on private agricultural lands in Jackson Hole, Buffalo Valley, the Gros Ventre River and Hoback River basins, and the Green River basin and the Red Desert would be similar to baseline conditions and Alternative 1.

In the long term, when supplemental forage was no longer provided under Alternatives 2 and 6,
some elk and bison would begin wandering off the refuge in search of forage, and a portion of the elk and bison populations that normally would have wintered on the refuge would instead begin wintering in other parts of Jackson Hole, the Buffalo Valley area, the Gros Ventre River basin, and possibly the Hoback River basin, the Snake River Canyon, the Wind River basin, and areas in Idaho such as Teton Valley north to areas east of Afton. Under Alternative 3 there could be fewer adverse impacts because a relatively small number of elk and potentially a large number of bison would be fed on the refuge during severe winters. Although most elk and bison would remain on federal lands during the fall, winter, and early spring, some could find their way onto private agricultural lands, resulting in adverse impacts.

The biggest concerns from the standpoint of ranchers would be competition for forage on private pastures and rangelands (both standing forage and along feedlines), increased potential for disease transmission to livestock, damage to fences, and safety (Williams, pers. comm. 2003). However, elk would likely be hazed to existing state feedgrounds or federal lands, and bison would either be hazed back toward the refuge or the park, or the Wyoming Game and Fish Department would have the prerogative to carry out special hunts or cull animals from the herd. No feedgrounds exist in Buffalo Valley, so hazing elk to feedgrounds would not be an option. To the extent that elk found their way to the Green River basin, they either would graze at one of the state feedgrounds along the perimeter of the basin or could be hazed to one of the feedgrounds.

If, however, large numbers of elk began migrating to the Green River basin and the Red Desert and were not shortstopped by state feedgrounds, competition with livestock for forage and depredation of hay and other crops on agricultural lands in the Gros Ventre River drainage, the Hoback River drainage, and the Green River basin would likely increase. Impacts could be moderate to major in localized areas, but overall effects on agricultural production throughout these drainages and basins would likely be negligible to minor.

In terms of potential effects on standing vegetation in private agricultural fields, competition with livestock for forage during the fall and early spring could be the largest effect if all feedgrounds were phased out and large numbers of elk annually migrated to the Green River basin. Increased distribution of elk would not be expected to reduce hay production or the production of any other agricultural crop, except possibly during the early spring when elk migrate back to summer ranges. In early spring, elk graze on early green-up as it is available, and this could cause damage in localized areas on private lands, especially in alfalfa fields (Bennett, pers. comm. 2004); however, elk generally move fairly quickly from wintering areas to transitional and summer range (C. Anderson 1958; BLM 1981; Irwin 2002), and therefore, the effects of spring grazing during the critical growth stage of plants could be light. Nonetheless, it is assumed that some adverse impacts to growing crops would likely occur in localized areas.

Over time, elk hunting would likely be adjusted, which would result in more pressure on elk on private lands during the fall and early winter. Despite adjustments to hunting regulations, it is possible that adverse impacts to agricultural lands would continue in localized areas under these alternatives over the long term. No damage to soil or the ability of private lands to produce agricultural crops would be anticipated.

**Alternative 4**

In the short term effects of elk and bison on private agricultural lands in Jackson Hole, Buffalo Valley, the Gros Ventre River basin, the Hoback River basin, the Green River basin, and the Red Desert would be similar to baseline conditions and Alternative 1.

In the long term some elk and bison could venture onto private agricultural lands in Jackson Hole and the Buffalo Valley area, the Gros Ventre River basin, and the Hoback River basin during some winters. Enhanced winter range and cultivated forage on the refuge, and fewer winter elk and bison (compared to current numbers that are above objective) would help keep elk on the refuge. But with reduced supplemental feeding on the refuge, some elk would likely move to other areas. Preventing access to food/hay on private lands would be vital for effective management. The agencies would work with the Wyoming Game and Fish Department and landowners, including the local livestock community, to coordi-
nate actions to prevent conflicts and to defray the costs of managing conflicts.

Elk that showed up in the Gros Ventre and Hoback River basins due to declines in supplemental feeding on the refuge would likely be hazed onto state feedgrounds before they began causing damage to private lands. Bison could be either hazed or culled. Nonetheless, it is possible that adverse impacts could occur to private agricultural lands in localized areas. In the Buffalo Valley area, impacts to agricultural areas could increase even though elk would likely be hazed and harvest strategies would be adjusted to reduce specific components of the elk herd.

**CUMULATIVE EFFECTS**

**TRANSPORTATION IMPROVEMENTS**

The reconstruction of U.S. 26/287 west of Togwotee Pass would result in short-term ground disturbance of 275 acres total during construction. Habitat types that could be disturbed include willow riparian and irrigated hayfields (33.0 acres), sagebrush park and meadow (5.5 acres), cottonwood riparian, (19.2 acres), mixed forest (52.3 acres), willow riparian, sagebrush park, and spruce / fir / pine mix (44.0 acres), spruce / fir (71.5 acres), aspen / lodepole pine mix, aspen and sagebrush park (30.3 acres), and lodepole pine / sagebrush park / willow riparian (19.2 acres). All disturbed areas not occupied by highway facilities would be promptly reclaimed, further reducing long-term impacts. Given the hundreds of thousands of acres of native habitat in the Jackson Hole area, the disturbance of 275 acres, in conjunction with the impacts of the proposed bison and elk management alternatives, would have a negligible effect on vegetation communities in the analysis area. The proposed alternatives would not contribute to the effects of the planned transportation improvements on habitat.

**FEDERAL LAND MANAGEMENT ACTIVITIES**

**Grand Teton National Park Fire Management**

Planned fire management actions could result in a reduction in some habitat types and reduced habitat quality in the short term. Prescribed fire can be used to maintain and restore more diverse vegetative communities in landscapes where natural fire regimes have been disrupted. Prescribed fires may, in the short and long terms, alter plant communities, but in the long term more vegetative diversity is created, and replicating natural fire regimes promotes plant succession. Habitat types affected by the park’s fire management actions would benefit in the long term due to the restoration of natural processes.

Alternative 1, in combination with the effects of planned fire management actions, would not result in cumulative effects. Restoring 4,500 acres of agricultural lands to native vegetation under Alternatives 2-6, together with fire management activities, would result in beneficial, cumulative, long-term effects.

**Grand Teton National Park Recreation Infrastructure Improvements**

The proposed implementation of multi-use pathways, the realignment of portions of the Moose-Wilson Road, and other transportation improvements would result in the loss of about 55 acres of habitat along existing transportation corridors. In addition, any future improvements to the Gros Ventre campground would result in site-specific, temporary habitat impacts during construction. Effects would likely be negligible because the areas already have been altered, and developed area footprints would not be significantly increased.

Alternative 1, in combination with the effects of park infrastructure improvements, would not result in cumulative effects. Converting formerly cultivated areas to native vegetation under Alternatives 2-6, combined with the impacts of infrastructure improvements, could result in negligible, short-term, adverse, cumulative impacts. In the long term restoring native vegetation on 4,500 acres of formerly cultivated lands would likely offset negative impacts of infrastructure improvements.

**Bridger-Teton National Forest Fuels Management Projects**

Bridger-Teton National Forest has identified a variety of fuels reduction and habitat enhancement projects in the primary and secondary analysis areas. These ongoing projects would alter over 5,400 acres of national forest land and would reduce certain habitat types following various fuel
reduction treatments. Some habitat types, such as native grasslands, would benefit in the long term at the expense of other habitat types, such as conifer forest.

Because supplemental feeding would be reduced or eliminated under several management alternatives (Alternatives 2, 3, 4, and 6), more elk could winter on native range and potentially move into these forest project areas. Treated habitats would result in more plant diversity but would also experience increased grazing and browsing. Habitat treatments in the national forest could offset to some extent the deterioration of woody vegetation on the refuge. These forest projects would not result in cumulative impacts under Alternatives 1 and 5 because elk would continue to be supplementally fed in most years on the refuge, preventing increased use of native transitional and winter range.

**BLM Upper Green River Special Recreation Management Area**

Actions planned in the Upper Green River Special Recreation Management Area would improve sensitive riparian vegetation zones that are now adversely affected. However, sagebrush areas would experience negative impacts as campsites, roads, and parking areas were reduced and some areas of this habitat type degraded. Cumulative impacts under all alternatives are expected to be negligible because of the small amount of acreage (16.5 acres) that would be directly impacted. None of the bison and elk management alternatives considered in this environmental impact statement would contribute measurably to these effects and would not result in cumulative effects on habitat in this area.

**Pinedale Anticline Oil and Gas Exploration and Development Project**

Oil and gas development activities in the Pinedale anticline project area would disturb vegetation communities due to the location of well pads, roads, pipelines, and other facilities. Standard management practices and mitigation would be implemented to protect vegetation and ensure that disturbed areas were properly restored. None of the bison and elk management alternatives considered in this environmental impact statement would contribute measurably to these effects and would not result in cumulative effects on habitat in the Pinedale anticline study area.

**Jonah Infill Drilling Project**

The Jonah infill drilling project is expected to result in additional well development and is anticipated to result in significant impacts to vegetation due to loss of habitat, forage, and soil protection, as well as increased potential for invasive, nonnative species. The project includes specific management requirements and mitigation measures; therefore, impacts to vegetation would depend on the effectiveness of these measures. None of the alternatives considered in this environmental impact statement for bison and elk management would contribute measurably to these effects and would not result in cumulative effects on habitat in the Jonah infill project area.

**Snake River Restoration Activities**

The restoration project by the U.S. Army Corps of Engineers along the Snake River would prevent further degradation of habitat and facilitate habitat recovery. Work would be confined to gravel bars or gravel channels within the river corridor, and no loss of riparian habitat is anticipated. In the long term woody riparian habitats and wetlands would benefit as natural processes were restored and these habitat types increased.

Of the alternatives considered in the bison and elk management plan, Alternatives 1 and 5 would continue supplemental feeding on the refuge in most years, alleviating any need for increased foraging by elk in Snake River riparian areas. Conversely, Alternatives 2, 3, 4, and 6 would increase elk distribution in some or all years, and the effects of increased elk grazing and browsing along the Snake River could offset to some extent the beneficial effects of improving and increasing the riparian habitat along the river.
This section describes the effects of the alternatives on elk herd numbers, distribution, movements, calf production, mortality, and the health of elk inhabiting the National Elk Refuge and Grand Teton National Park, as well as the entire Jackson elk herd. It also identifies and explains the factors that would influence the population and that would lead to the population effects described below.

**METHODOLOGY USED TO ANALYZE WILDLIFE IMPACTS**

Sources of information used to assess the level of impact on wildlife included: (1) scientific literature on species’ life histories, distributions, habitat selection, and responses to human activities; (2) site-specific information on wildlife species in the park, the refuge, state and national forest lands, including complete and ongoing studies (when available); and (3) the professional judgment of park, refuge, state, and forest biologists and managers familiar with management concerns related to individual species.

In addition, for impacts on elk analytical specialists were contracted to perform computer-modeling of forage allocation and the elk population using elk population data and a variety of bison population sizes. The models predicted changes in population parameters under the various alternatives and assisted in explaining factors behind historical trends. The results were used as a tool to help predict the number of elk and bison that could exist under each alternative and to assess the effects of climatic variation and forage enhancement on elk and bison numbers and other population parameters such as distribution, mortality, and sustainability. As previously described, when winters are referred to as average, above-average, or severe in the text, snow accumulations would be similar to those used in modeling for the impact analysis (Hobbs et al. 2003). These rankings were based on 50 years of estimated inches of snow-water equivalent (the amount of water stored as snowpack) at the Hunter-Talbot hayfields in Grand Teton National Park (Farnes, Heydon, and Hansen 1999). Snow-water equivalent was considered the best measure for predicting how ungulates would respond to winter conditions. The winter of 1996 was designated as average, 1982 as above average, and 1997 as severe.

The threshold for the effect of snow-water equivalents on forage availability can be difficult to measure in the field. Some of the assumptions in the model relied on professional judgment and observations of elk behavior. Snow conditions can affect this threshold and are not represented in the model. For example, if crusting of snow makes forage less available at lower snow-water equivalents, then model predictions for an average winter could tend to be more like those for a severe winter, and predictions for a mild winter could more closely resemble those for an average winter.

Identifying variables that are measurable early in the winter to determine winter severity and, under some of the alternatives, whether supplemental feeding should occur in a given year would be critical. Refuge and WGFD personnel would continue to jointly evaluate forage availability. Preliminary analyses indicate that the index of winter severity calculations for the Blacktail/Gros Ventre area for January 1 are strongly correlated with the supplemental feeding start date on the refuge and could be a useful tool for early winter evaluations (E. K. Cole 2005). When calculating the index of winter severity for elk, snow, temperature, and forage variables are weighted at 45%, 35%, and 20%, respectively (Farnes, Heydon, and Hansen 1999).

Elk numbers were estimated using a variety of methods, including the PopII model (Fossil Creek Software 1999) and data from ground and aerial (helicopter) censuses. These censuses are conducted in a single day in February of most years to count and classify elk by age and sex to help ground-truth modeling results. Overall, modeled projections varied from total herd counts by about 10%–15%, primarily due to sightability problems on native winter range. Native winter range counts were adjusted for sightability bias to provide a more accurate idea of actual elk numbers on native winter range. When feedground counts
were subtracted from WGFD modeled total herd estimates, it was determined that, on average, about 66% of elk on native winter range were counted during censuses. This percentage agreed with the estimate by Lubow and Smith (2004) of 66.3% sightability. Because native winter range counts represented two-thirds of the total elk estimated on native winter range, these counts were increased by half to approximate actual numbers on winter range.

It is understood that in all alternatives except Alternative 2 the U.S. Fish and Wildlife Service and the National Park Service would work cooperatively with the Wyoming Game and Fish Department to achieve population objectives, including herd ratios and elk herd segment sizes; to establish hunting seasons; and to evaluate hunting/elk reduction areas. The state would formally establish objectives and strategies after public review and approval by the Wyoming Game and Fish Commission.

The analysis of disease-related impacts is based on synthesis of information from three primary sources: (1) disease experts from the U.S. Fish and Wildlife Service, the National Park Service, the U.S. Geological Survey, the Animal Plant and Health Inspection Service, the Wyoming Game and Fish Department, and the Wyoming Livestock Board; (2) published scientific literature; and (3) unpublished data and reports from the refuge and the park. A three-day meeting of disease experts from the agencies listed above was held November 12–14, 2002. The session was interactive, with experts discussing disease impacts to elk and bison that could result from implementing each of the six management alternatives. Impact topics associated with each disease that were discussed included prevalence in the herd; production and recruitment; mortality; demographics and distribution; and transmission of the disease to elk, bison, livestock, humans, other ungulates (mule deer, moose, pronghorn, bighorn sheep), predators and scavengers (black bears, coyotes, ravens, crows), and threatened and endangered species and sensitive species (wolves, grizzly bears, bald eagles, trumpeter swans). Some diseases were discussed in more detail than others, due to higher potential for impacts to wildlife, livestock, or humans (e.g., brucellosis).

The primary factors considered by disease experts that differ among alternatives were numbers of animals (elk and bison), animal density, intensity and duration of supplemental feeding, animal distribution on the landscape, elk and bison migrations, habitat improvements, and potential for contact between elk/bison and livestock or humans. All of these factors, individually or in combination, can influence the impacts of diseases in wildlife populations.

In cases where major differences in opinion existed between disease experts, both viewpoints are documented. For this planning process a thorough literature review was conducted for additional information on the diseases of concern (Peterson 2003). This review summarized what is known regarding infectious agents that currently affect, or could in the future affect, Jackson elk and/or bison, places this information in an ecological context for use in management decision-making, and points to areas where, from an ecological perspective, more information is needed.

The analyses were quantitative wherever data allowed. Where sufficient numeric information was not available, qualitative or relative assessments were made. During the disease expert meeting, the following impact levels were defined; these impact levels are applied throughout the disease portions of the environmental consequences section where sufficient information to determine the degree of impact exists:

- **Negligible** — The impact would be at the lower levels of detection (5%–10% change).
- **Minor** — The impact would be slight, but detectable (11%–25% change).
- **Moderate** — The impact would be readily apparent and would have the potential to become major (26%–79% change).
- **Major** — The impact would be severely detrimental, or if beneficial, would have exceptional beneficial effects (80% or greater change).

Discussion of direct, indirect, secondary, short-term (less than 5 years), long-term (15–20 years or longer), and cumulative impacts are included as appropriate. The effects of Alternative 1, and all other alternatives relative to Alternative 1, are documented. Potential mitigation measures that
could be implemented to reduce impacts are included where appropriate. Throughout the disease impact analysis, the focus is on elk that winter on the refuge, although impacts on the entire herd are also discussed.

For some diseases, such as chronic wasting disease, little is known regarding the epidemiology of the disease, and disease experts were unable to predict impacts precisely enough to fit into the threshold levels identified above. In such cases, relative impacts under the alternatives were ranked that could result based on what is known about the disease.

When comparing impacts of Alternatives 2–6 to Alternative 1, it was assumed that the increasing bison population under Alternative 1 would remain on the refuge during winter because the supplemental feeding program would encourage bison to stay there.

The following diseases of concern include the primary diseases that experts believe could have impacts on the Jackson elk and bison herds. Wildlife in the project area could be susceptible or exposed to many other diseases, but the biological significance of these other diseases in the project area is minimal; therefore, these diseases were not included. The diseases of concern that are analyzed in depth include the following (for a discussion of diseases that would not be affected by elk and bison management, and therefore are not analyzed in depth, see the discussion beginning on page 129):

- **Macroparasites** (parasitic arthropods and helminths) documented in the Jackson elk or bison herds — psoroptic scabies, helminths and lungworms
- **Bacterial microparasites documented in the Jackson elk or bison herd** — necrotic stomatitis, septicemic pasteurellosis, bovine brucellosis.
- **Bacterial microparasites not documented in the Jackson elk or bison herd** — bovine tuberculosis and paratuberculosis (Johne’s disease). There are no impacts at present from bovine tuberculosis or paratuberculosis. The discussion of potential impacts is addressed in the context of the effects each alternative would have on transmission and prevalence if either of these diseases was introduced. Because bovine paratuberculosis is primarily a disease of bison, with only rare, scattered instances of paratuberculosis positive elk reported without documentation of mortality (Roffe, pers. comm. 2005), impact discussion focuses on the bison herd.
- **Viral microparasites not documented in the Jackson elk or bison herd** — malignant catarrhal fever
- **Prion microparasites not documented in the Jackson elk or bison herd** — chronic wasting disease. There are no impacts at present from chronic wasting disease. The impact analysis focuses on the effects that each alternative would have on transmission and prevalence if this disease became established.

To avoid redundancy, some of the disease discussion in the following impact analysis covers effects on both bison and elk. Effects are treated separately when greater detail is needed.

**IMPACTS OF THE ALTERNATIVES**

**IMPACTS COMMON TO ALL ALTERNATIVES**

**Disease Impacts**

Although the prevalence of brucellosis would vary among alternatives, brucellosis would not likely be eradicated from the portion of the Jackson elk herd utilizing the refuge under any alternative, even using Strain 19 vaccine (Gross, Miller, and Kreeger 1998; Kreeger and Olsen 2002; Roffe et al. 2002). Therefore, brucellosis-induced abortions would likely continue to occur at some level under all alternatives. Some potential for brucellosis transmission between elk and bison would thus remain under all alternatives.

Brucellosis has the potential to cause cow elk to abort or elk calves to become sick and may currently be reducing calf production by up to 5% on the refuge (Oldemeyer, Robbins, and Smith 1993, as adjusted for lower seroprevalence in recent years). This translates to a small loss in elk numbers overall, as adults do not generally die from brucellosis (Dobson and Meagher 1996), and the herd itself has a high intrinsic potential to increase (Lubow and Smith 2004). As an example of the small loss current levels of brucellosis on the refuge could cause, if the calf-to-cow ratio was 25
calves to 100 cows, a 5% reduction in calf production would result in a ratio of 23.75 calves to 100 cows. Unless prevalence rose on the refuge, this loss would only slightly change the demographics of the Jackson elk herd. Because brucellosis would have only negligible impacts on the Jackson elk herd demographics, no impacts on the distribution of elk on the refuge or in the park are expected as a result of brucellosis under any alternative.

Brucellosis can cause lameness in chronically infected adult elk and may increase winter deaths of a small percentage of infected elk through predation or starvation (Thorne et al. 1982). Few, if any, adult elk deaths related to brucellosis would be expected, and impacts on adult mortality would be negligible at most.

Brucellosis may be transmitted to other ungulates, predators, scavengers, and other wildlife species (including threatened, endangered, and sensitive species), but aside from bison, these species are most likely dead-end hosts (Davis 1990; Thorne 2001). Brucellosis is not expected to directly adversely impact populations of any of these species (Thorne et al. 1982; Disease Expert Meeting 2002), and these species are not expected to transmit the disease to other species or conspecifics. Therefore, under all alternatives, no direct impacts to these species would occur as a result of brucellosis transmission from the Jackson elk herd.

No direct impacts on elk mortality, production, and recruitment are expected under any alternative as a result of lungworm infection.

Necrotic stomatitis is not a transmissible disease. Thus, transmission between elk would not occur under any of the management alternatives.

If chronic wasting disease was found in an elk from the Jackson elk herd, 50 elk would be removed within 5 miles of the index case. If another infected elk was found, another 50 would be removed within 10 miles of the positive case, and so on. This disease management strategy, as well as potentially decreasing densities through hunting or other means, would increase elk mortality under all of the alternatives.

**Competition for Forage by Livestock Grazing**

Competition for forage between elk, bison, and cattle in Grand Teton National Park, Bridger-Teton National Forest, and some private lands in Jackson Hole, Buffalo Valley, and the Gros Ventre River basin is discussed under each alternative under “Social and Economic Impacts: Impacts on Livestock Operations, Competition for Forage.”

While competition for forage between elk and cattle would occur to a limited extent in the park, the effect of cattle grazing is negligible for several reasons. The amount of cattle grazing that is permitted is low and continues to decline. In 2005 and 2006 there were only 160 cow-calf pairs in the park, and some allotments were not used. Summer habitat for elk is abundant, and cattle are not grazed on winter range (i.e., they are not in areas where forage is available in the winter).

**TABLE 4-5: ESTIMATED NUMBER OF ELK ON THE NATIONAL ELK REFUGE, IN THE GRAND TETON NATIONAL PARK SEGMENT, AND TOTAL IN THE JACKSON HERD UNIT**

<table>
<thead>
<tr>
<th></th>
<th>Wintering on the National Elk Refuge</th>
<th>Grand Teton National Park Segment</th>
<th>Total in Herd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing (1997–2001)</td>
<td>7,056</td>
<td>3,238</td>
<td>14,641</td>
</tr>
<tr>
<td>Alternative 1</td>
<td>5,574</td>
<td>2,676</td>
<td>11,000</td>
</tr>
<tr>
<td>Alternative 2</td>
<td>1,200–6,000</td>
<td>576–2,880</td>
<td>8,100–11,000</td>
</tr>
<tr>
<td>Alternative 3</td>
<td>1,000–2,000</td>
<td>500–1,000</td>
<td>7,900–11,000</td>
</tr>
<tr>
<td>Alternative 4</td>
<td>Approximately 5,000</td>
<td>Approximately 1,600</td>
<td>11,000</td>
</tr>
<tr>
<td>Alternative 5</td>
<td>5,574&lt;sup&gt;4&lt;/sup&gt;</td>
<td>&lt;2,500</td>
<td>11,000</td>
</tr>
<tr>
<td></td>
<td>5,000–7,500&lt;sup&gt;2&lt;/sup&gt;</td>
<td>&lt;2,500</td>
<td>13,000–15,000</td>
</tr>
<tr>
<td>Alternative 6&lt;sup&gt;3&lt;/sup&gt;</td>
<td>2,400–3,200</td>
<td>1,200–1,600</td>
<td>9,300–11,000</td>
</tr>
</tbody>
</table>

1. Assuming that the herd is maintained at the herd objective. When the herd is at objective, it is estimated that elk numbers on the National Elk Refuge would average approximately 5,574.
2. Assuming that the herd is allowed to exceed the herd objective; that is, 7,500–8,500 elk on the National Elk Refuge would require that the herd objective be exceeded by a moderate to major amount.
3. After a series of above-average or severe winters, numbers could drop to the low number shown for Alternative 2.
**ALTERNATIVE 1**

**Analysis**

In the following sections, short- and long-term effects are discussed together unless otherwise noted.

Under Alternative 1 the refuge would continue to provide both standing forage and pelleted hay to as many as 7,500 elk. Annual fluctuations in numbers would continue to occur but on average 5,000–7,500 elk would winter on the refuge. Supplemental feeding would occur for an average of 70 days during 9 of every 10 years. In 2005 approximately 7,000 elk wintered on the refuge. The 20-year average has been about 8,000, but numbers have ranged from approximately 5,000 to 11,000. For the purposes of this analysis it is assumed that the 1974 Memorandum of Understanding with the Wyoming Game and Fish Department, which sets an upper limit of 7,500 elk on the refuge, would be met. In addition, if the Jackson elk herd objective was met and maintained, the average number of elk on the refuge would be approximately 5,600. This number is the average of elk counted during five of the last six winters (a partial count was not included), adjusted for a Jackson elk herd size of 11,000, and it is considered the baseline in these analyses for the number of elk wintering on the refuge.

Other numbers of elk in the region would also remain the same under Alternative 1. These are detailed in the Chapter 3 and summarized here. The number of elk on native winter range currently averages about 4,400 to 7,800, and the objective for this segment of the herd (i.e., when the entire herd numbers 11,000) is 3,700. Elk on winter range in the park number about 535, and range between 200 and 1,300 (WGFD 1989–2002). The objective for elk on native winter range in the park (i.e., when the herd is at 11,000) would be 356, with an estimated range of 137 to 857. Elk numbers in the entire Jackson herd are currently estimated at 12,855 (winter 2005–6) and have ranged from 12,610 to 19,657 during the period 1989 to 2006.

Under Alternative 1 the number of elk on native winter range would be expected to remain similar to baseline conditions (2,900 to 5,200 elk), and averaging approximately 3,700.

Alternative 1 also assumes that approximately 2,500 elk would continue to be fed annually on three feedgrounds in the Gros Ventre River drainage. Using counts for the refuge (5,876) and the Gros Ventre feedgrounds (2,839) and the WGFD PopII estimate for total herd size, 65% of the total Jackson elk herd was fed in the winter of 2003–4.

**Distribution and Movements of Elk**

About half of the total Jackson elk herd would continue to winter on the refuge under Alternative 1, of which between 19% (Anderson et al. 1998; GTNP unpubl. data) and 48% would come from the park segment, 12% from the Gros Ventre segment, 12% from the Teton Wilderness segment, and 28% from Yellowstone National Park segment (Smith and Robbins 1994).

Existing management of the refuge (feeding, cultivation of standing forage, and prescribed fire to improve quality of forage), protection of elk inside park boundaries, and environmental conditions (shallower snow depth) would continue to attract elk to these lands. As a result, elk density on the refuge would continue to be increased by supplemental feeding, from an average of 0.5 elk per acre if elk were distributed equally on the southern areas of the refuge to 500 elk per acre at the feedgrounds during two-hour feeding periods.

Fall elk distribution and use of native transitional and winter ranges on and near the refuge and the park would continue to be influenced by hunting. Elk would attempt to move from open hunt areas to non-hunted portions of the park and the refuge.

**Elk Behavior, Social Interactions, and Nutrition**

A maximum of 7,500 elk currently occupy the refuge and are fed at four sites or through standing forage in most (9 of 10) years. This would continue under Alternative 1.

Elk would continue to habituate to the start of supplemental feeding operations within several days, and once habituated, they would not react adversely to feed trucks or the dispensing of pellets (B. L. Smith, pers. comm. 2002). Elk would continue to temporarily leave feedlines for various reasons, mostly associated with interactions between animals, but also if feeding operations did...
not progress in a familiar manner (B. L. Smith, pers. comm. 2002). Elk behavior would continue to vary from day to day. On most mornings elk would be close to where they were fed the day before, which would result in less movement and fewer interactions among elk. On Poverty Flats the supplemental feeding location would continue to vary daily, and over the course of several days feeding sites could be distributed over a large area. This would continue to require elk to move longer distances to feeding sites and could result in slightly higher levels of interaction as they converged on feedlines (Cole, pers. comm. 2002). It is expected that gorings by bull elk on feedlines would be rare, as the program has been fine-tuned over the last 30 years to reduce competition. Under baseline conditions, an estimated three to four gorings per year occur that result in substantial injury or death (B. L. Smith, pers. comm. 2002).

During periods of supplemental feeding, elk would continue to be concentrated along lines of alfalfa pellets. After eating at the feedlines, the elk would continue to disperse to nearby areas, rest during a large part of the day (Smith and Robbins 1984), and feed on native forage as they have in the past.

As the bison population grows, progressive displacement of elk from preferred forage on the refuge is considered likely (Telfer and Cairns 1979; Helprin 1992). Bison impacts on elk would be greatest during periods when high quality forage is in critical demand, such as during drought years and during especially cold or snowy winters. However, even during fall, bison may browse woody plants preferred by elk (Smith, Cole, and Dobkin 2004). Large numbers of bison could remove much of the forage elk would use, in addition to contributing to plant degradation through overuse. These impacts would become significant at some unknown bison population level.

Smaller amounts of standing forage would be available for elk on their wintering grounds, which could necessitate changes in the supplemental feeding program. To maintain up to 7,500 elk on the refuge, the amount of food provided might need to be increased repeatedly over time, and feeding might need to be initiated earlier each year in the long term.

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**Winter Supplemental Feeding for Elk**

Under Alternative 1 supplemental feeding would continue to affect various population parameters. In Jackson elk, feeding increases herd size, beyond numbers that would be present without supplemental feeding, by providing supplemental nutrition and limiting winter mortality to 1%–2%. It does not appear to alter pregnancy rates or calf production, as these rates are similar in fed and unfed elk populations (B. L. Smith 2001).

The feeding program would continue to enhance elk survival and maintain a larger population. It would also continue to increase brucellosis transmission and prevalence, compared to non-fed elk, as well as brucellosis-related abortions.

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**Disease Prevalence and Transmission**

Some of the disease discussion covers effects on both bison and elk to avoid redundancy.

**Bovine Brucellosis**

Under Alternative 1 brucellosis prevalence in the refuge portion of the Jackson elk herd, and the entire Jackson elk herd, would vary over time as it has in the past and would remain fairly high in the short term (seroprevalence rate since 1980 averaged approximately 28%; NER unpubl. data). In the long term the Jackson bison herd would continue to increase in numbers. As bison numbers continued to increase, the chance for contact between elk and bison would increase, particularly on the feedgrounds. Although the degree of risk for transmission from bison to elk would continue to increase, this risk might be negligible in the long term.

**Septicemic Pasteurellosis**

Because the epidemiology of this disease in elk is poorly understood (B. L. Smith 2001; see Chapter 3, page 133), impacts from the alternatives are discussed only in relative terms. Potential impacts on prevalence, and production/recruitment, and mortality from septicemic pasteurellosis would be highest under Alternatives 1 and 5 because of high numbers of elk on the refuge.

**Necrotic Stomatitis and Footrot**

As described in Chapter 3 (see page 133), necrotic stomatitis occurs in elk when coarse woody vegetation or grasses with large awns and seeds punc-
tire the soft tissue of the mouth or throat and become infected with *Fusobacterium necrophorum* (Leighton 2001). Most of the management alternatives are designed to balance elk and bison numbers with habitat and forage availability. When sufficient winter forage (either standing forage or supplemental feed) was available for elk, occurrence of necrotic stomatitis would be negligible and would not likely differ from the current two to three mortalities per year. Alternative 1, as well as Alternative 3, 4, and 5, would supply elk on the refuge with sufficient forage through native range habitat improvements, enhanced forage production through irrigation, and supplemental feeding in the worst winters. Impacts would be negligible.

Outbreaks of footrot may occasionally occur during feeding years, particularly when compacted, icy snow conditions and high elk densities on feedgrounds coincide.

**Psoroptic Scabies**

As described in Chapter 3 (see page 133), psoroptic mites are spread through direct contact, and prevalence in a herd is likely density related (Peterson 2003; Disease Expert Meeting 2002; Smith and Roffe 1994). There would be no additional impact on prevalence of psoroptic scabies in the elk herd in the long term under Alternative 1 because elk numbers and the supplemental feeding program would remain the same as baseline conditions.

**Helminths and Lungworms**

As described in Chapter 3 (see page 134), lungworm parasitism and lungworm infection is density dependent in elk (Disease Expert Meeting 2002). In the long term lungworm transmission among elk and prevalence in the Jackson elk herd would be greatest under Alternatives 1 and 5 because supplemental feeding would occur nearly every winter and high elk numbers would be maintained.

**Bovine Tuberculosis and Paratuberculosis**

These diseases are not currently affecting the Jackson elk or bison herds. However, if the Jackson elk and bison herds did contract bovine tuberculosis or bovine paratuberculosis, greater animal densities on the refuge and more frequent supplemental feeding would increase transmission (Williams 2001; Demarais et al. 2002), and subsequent prevalence and mortality. The relative risk of bovine tuberculosis and paratuberculosis becoming established in the Jackson elk or bison herds would be similar under a given management alternative. Therefore, impacts on the Jackson elk and bison herds from both diseases are discussed together, although bovine paratuberculosis should be considered primarily a disease of bison.

Only the relative risk of the Jackson elk and bison herds acquiring either bovine tuberculosis or paratuberculosis, or the impacts of its spread if the herd became infected, is presented. The most likely way the herd could contract either disease is from domestic livestock (Peterson 2003; Disease Expert Meeting 2002) or contact with captive cervids (Thorne et al. 1992).

Alternative 1 would provide an ideal environment for these diseases to be spread and maintained in the Jackson elk herd (Disease Expert Meeting 2002) due to the intensive supplemental feeding program and high elk densities (Demarais et al. 2002; Thorne et al. 1982; Thorne et al. 2002). If bovine tuberculosis became established in elk on the refuge, prevalence could be higher than in other herds (5.5% for an elk herd in Canada and 2.5% for a white-tailed deer herd in Michigan, for example) due to high winter density. Prevalence estimates for bovine paratuberculosis are not available, but it is thought that elk on the refuge could maintain infection (Disease Expert Meeting 2002). In addition to transmission between elk, Alternative 1 would also be most likely to result in transmission between bison and elk, as bison would continue to increase and the two species would mix.

**Malignant Catarrhal Fever**

As described in Chapter 3 (see page 136), no cases of malignant catarrhal fever have been reported in the Jackson bison or elk herd (HaydenWing and Olson 2003). The most effective control of this disease is preventing contact with hosts (e.g., domestic sheep), especially during calving or nursing periods (Heuschele and Reid 2001). The risk that this disease would infect the herd under Alternative 1 would be greater than under the other alternatives because more animals would be present and the chances that any one of them would
have had contact with infected sheep would also be higher.

**Chronic Wasting Disease**

As discussed in Chapter 3 (beginning on page 136), chronic wasting disease is transmitted between animals, but the exact mode of transmission is unknown (Williams, Miller, et al. 2002); however, transmission does appear to be related to the density of susceptible hosts and environmental contamination. Because so little about the means of transmission and other critical factors in predicting the potential risk of the disease is known, risk is only presented in relative terms.

Wildlife disease experts ranked the management alternatives based on the relative impacts that the disease might have on the Jackson elk herd, should it become established (Disease Expert Meeting 2002). Rankings were based on two primary factors: (1) supplemental feeding frequency and duration, and (2) the number of elk on the refuge. Prevalence of chronic wasting disease under Alternative 1 would be similar to that under Alternative 5, and greater than under Alternatives 2, 3, 4, and 6 (see Table 4-6).

If chronic wasting disease became established in the Jackson elk herd, it is likely that prevalence would fall within the range seen in free-ranging and confined elk, about 4% on average (2.3% to 9.6% range in Wyoming elk; WGFD, unpubl. data 2005), and up to 59% in game farm elk (Peters et al. 2000) or higher (71%) for small captive elk herds (Miller, Wild, and Williams 1998). Mortality would reflect prevalence and, depending on the extent of infection, negligible to major mortality might be expected in the long term. Prevalence and mortality would likely be highest under Alternatives 1 and 5 and lower under Alternatives 4 and 3. High concentrations due to supplemental feeding would not occur under Alternatives 2 and 6 after winter feeding was phased out, and prevalence would be lowest under these alternatives.

**Calving, Age and Sex Ratios, and Recruitment**

Influences on age and sex ratios from harvest strategies under Alternative 1 would likely remain similar to those under existing conditions. The practice of supplemental feeding has not been shown to alter pregnancy rates and calf production as these rates are similar in fed and unfed elk populations (Peek et al. 2002; B. L. Smith 2001). At present, the Wyoming Game and Fish Department is emphasizing antlerless harvest in order to lower herd size to the objective of approximately 11,000 elk, as well as to decrease hunting pressure on antlered elk (WGFD “2002 Annual Big Game Herd Unit Report”). If fewer antlerless tags are issued after the herd is at objective levels, fewer calves might be harvested, resulting in higher calf-to-cow ratios.

Brucellosis would negligibly impact production and recruitment rates for the portion of the Jackson elk herd that winters on the refuge and the entire Jackson elk herd in the short term under Alternative 1.

Impacts to production and recruitment from septicemic pasteurellosis would be tied to mortality levels, as reproduction is unaffected. Impacts on production and recruitment under Alternative 1 would be similar to those under Alternative 5, and greater than under Alternatives 2, 3, 4, and 6.

The Jackson elk population is not currently infected by bovine tuberculosis, bovine paratuberculosis, or chronic wasting disease. If these diseases became established in Jackson Hole, they would affect productivity; and if mortality was additive, they could affect recruitment. Numbers of calves produced each year could decline, with a smaller population size and fewer adult females.
These diseases could also affect age ratios because older animals would be more susceptible.

If bovine tuberculosis or paratuberculosis became established in the herd, it is likely that the impact on production would be low. For example, if prevalence of either disease was similar to that known to occur in other herds (5.5% prevalence for a Canadian elk herd; Hadwen 1942). This would constitute a negligible decrease in production and recruitment. However, higher elk densities than occur under free-ranging conditions could mean higher prevalence and greater losses. Age ratios could change in the long term because older animals may have higher prevalence (Rodwell, Whyte, and Boyce 2001) and higher mortality rates.

Impacts from chronic wasting disease would also be caused indirectly through changes in mortality, the level of which would depend on prevalence in the herd. Experts believe prevalence would lie between levels found in free-ranging elk (4% on average) and confined elk (up to 59% or higher). Relative impacts on production and recruitment under Alternative 1 would be similar to those under Alternative 5, and greater than under Alternatives 2, 3, 4, and 6 (see Table 4-6). Rankings were based on supplemental feeding frequency and duration, as well as on the number of elk wintering on the refuge.

Mortality

Excluding harvest, annual mortality of mature elk (age 1 or older) in the Jackson herd is expected to remain similar to current estimates of approximately 3% (Lubow and Smith 2004). Winter elk mortality on the refuge would continue to remain at current low levels of 1%–2% of the population because nearly annual supplemental feeding alleviates the effects of occasionally severe winters and inaccessible native vegetation due to deep snow. Deaths would continue to result primarily from natural causes, disease, and vehicle collisions. Mortality levels would remain low under Alternative 1 unless non-endemic diseases infected the elk herd or competition for standing forage with bison caused increased mortality.

Early calfhood mortality would continue to be variable and higher than that of older elk. Mortality of radio-collared elk calves, assessed in 1990–92 and in 1997–99, increased from 15.2% of calves to 27.5% during the second study period. Elk calves were smaller, had slower growth rates, and the period in which deaths occurred was longer in 1997–99 than in the initial study period, probably due to cool April temperatures and larger total elk numbers (B. L. Smith et al. 2006). The neonatal loss of 15% was similar to mortality in Colorado elk (Bear 1989) and red deer in Scotland, areas with minimal predation, and it was considerably less than the 31% loss in Yellowstone National Park (Singer et al. 1997) and 66% in Idaho (Schlegel 1976).

Of the diseases described above, only septicemic pasteurellosis is both potentially fatal and currently present in the Jackson herd. Mortality from this disease in the refuge herd has been negligible and would likely vary with the number of elk and frequency and duration of supplemental feeding. Mortality under Alternative 1 would be expected to be similar to what would occur under Alternative 5, and greater than under Alternatives 2, 3, 4, and 6.

Mortality related to other potentially fatal diseases not yet in the herd would vary similarly if the herd became infected, but higher numbers of bison under Alternative 1 could increase impacts from some diseases. Potential prevalence and mortality from diseases such as bovine tuberculosis, bovine paratuberculosis, and chronic wasting disease would depend on density, number of elk and/or bison at the refuge, and the frequency and duration of supplemental feeding.

Because higher bison numbers could increase mortality due to bovine tuberculosis or bovine paratuberculosis, prevalence and potential mortality would be highest for these diseases under Alternative 1. Potential prevalence and mortality in the long term would likely be higher than the 5.5% described for a Canadian elk herd (Hadwen 1942) because of high densities, growing bison numbers, and the intensive supplemental feeding program on the refuge. Because these diseases are chronic and develop slowly, and older animals tend to have higher probability of being infected (Rodwell, Whyte, and Boyce 2001) and exhibiting clinical symptoms, adult elk mortality would increase in the long term as the number of clinical cases increased.
Bison numbers would not affect chronic wasting disease in elk wintering on the refuge, and mortality would be similar to Alternative 5 and greater than under Alternatives 2, 3, 4, and 6. If the Jackson elk herd became infected, prevalence would likely fall within the range seen in free-ranging elk, about 4% on average (2.3% to 9.6% in Wyoming elk; WGFD, unpubl. data 2005) and ranging up to 59% or higher in confined elk (Peters et al. 2000; Miller, Wild, and Williams 1998).

Harvest strategy would continue to be the primary cause of mortality in the Jackson elk herd and would likely remain similar to current management under Alternative 1. There could be a decreased emphasis on antlerless harvest after the herd objective of 11,000 elk was reached. Management actions under this alternative would not change low levels of predation on the elk herd.

**Health, Sustainability, and Naturalness**

The Jackson elk herd could maintain relatively good health and continue to be self-sustaining under Alternative 1 if its current disease status and health conditions persisted and a serious non-endemic disease did not infect the herd. However, both bison and elk would be fed under this alternative, regardless of the size of the populations on the refuge, and it is assumed that the bison population in particular would increase dramatically over time. This concentration of animals would present a high risk of transmitting existing and new diseases, thereby jeopardizing herd health and sustainability in the long term.

Barring the introduction of serious non-endemic disease, the herd would continue to be genetically viable. Under Alternative 1 the herd would continue to be strongly affected by management programs. Harvest would influence parameters such as elk numbers, mortality, movements, seasonal distribution to an extent, age and sex ratios, and breeding ratios. Supplemental feeding would influence numbers, nutritional status, mortality, disease, and movements and distribution.

Due primarily to elevated disease risks, long-term health and sustainability of the elk herd would be lower under Alternative 1 than any other alternative.

Under this alternative management would continue to affect the distribution of the population. Rather than many groups of elk roaming in search of available forage, as occurred naturally, the refuge portion of the herd and other elk in the Jackson elk herd using feedgrounds would continue to be concentrated together in a relatively small area for several months each winter.

Several population processes would continue to operate at unnatural levels. Notably, winter mortality would be much lower than natural due primarily to the supplemental feeding program on the refuge. Under natural conditions, mortality rates are different among age and sex classes, but winter feeding would tend to nullify these differences. Also because of the winter feeding program, production and recruitment rates would be unnatural and calves that are born out of the normal calving season would continue to have a high chance of survival.

Of all alternatives, Alternative 1 would result in the lowest level of naturalness in the elk herd even though some aspects of naturalness (e.g., sex ratio, fewer hunter-killed bison) would be higher than under some alternatives.

**Conclusion**

In the long term under Alternative 1 an estimated 11,000 elk would be in the Jackson elk herd. Elk numbers would remain similar to baseline conditions. Reduction of the herd to objective size through hunting would alter numbers to a minor extent. The herd size would be similar under Alternatives 1, 4, and 5, and probably Alternative 6.

Movements and distribution would be similar to baseline conditions in the long term due to nearly annual winter supplemental feeding on the refuge. Large concentrations of elk would continue to focus in winter on feedgrounds and nearby areas during periods of supplemental feeding. Recruitment and annual winter survival would remain higher than in non-fed populations in similar environments. Bison numbers would continue to grow, increasing competition with elk for available forage on the refuge, and would likely increase the level of winter feeding.

Habitat conservation and management on the refuge would continue to provide a beneficial effect...
through increasing available standing forage and habitat. Under Alternative 1 these benefits to elk could gradually be eroded as the bison herd increased.

The risk for a non-endemic infectious disease quickly spreading through the elk population would be the highest of any alternative, due primarily to the winter feeding program and the growing number of bison. Therefore, this alternative would have the greatest risk of a non-endemic infectious disease having a major adverse impact on survival, population size, and sustainability. The prevalence of brucellosis in the elk herd would remain similar to baseline levels initially and could increase with a larger bison population and more interactions between elk and bison on the refuge.

Of all alternatives, Alternative 1 would result in the lowest level of long-term health, sustainability, and naturalness in the elk herd.

Due to continued large concentrations of elk on refuge feedlines and growing concentrations of bison on feedlines, there would be an elevated potential for the elk population to be impaired if a non-endemic infectious disease became established in the elk herd. Otherwise, Alternative 1 would not cause impairment to the elk population in the park.

**ALTERNATIVE 2**

Alternative 2 would minimize human influence on the elk herd. Little would be done to enhance native winter forage and the use of imported feed on the refuge during the winter would be phased out. Ending this program would be accomplished gradually in the short term, by eliminating supplemental feeding in mild winters, then in average winters, and so on. During the latter part of the short-term period, feeding would only occur in winters of above-average and severe snow conditions. Hunting on the refuge and in the park would be stopped.

**Analysis**

**Numbers of Elk Wintering on the National Elk Refuge and on Native Winter Range**

**Short-term Effects**

During the first few years of the initial 10- to 15-year period, elk numbers on the refuge would increase due to the elimination of hunting on the refuge and in the park and continued low levels of mortality associated with the supplemental feeding program on the refuge. Numbers of elk wintering on the refuge could also increase as more and more elk in adjacent areas learned that the refuge had become a safe zone (B. L. Smith, pers. comm. 2003). Without supplemental feeding, a greater number of elk would switch to feeding on native winter range in the analysis area. Although the number of elk on native winter range would vary annually according to the severity of the winter and the stage of the feeding program reduction, numbers would increase during non-feeding years above the estimated 4,400–7,900 that have used native range during the last 15 years. Elk numbers wintering on native range would remain similar to these numbers during feeding years but would decrease gradually as the Jackson elk herd approached the 11,000 objective.

**Long-term Effects**

Estimates based on the forage accounting model by Hobbs et al. (2003) indicate that the refuge would overwinter between 1,200 and 6,000 elk without supplemental feeding. The current number of elk on the refuge is larger than available native forage can sustain and has been kept artificially high with supplemental feeding. Without forage cultivation and when feeding was completely discontinued, elk numbers on the refuge would presumably drop to within these numbers, and more elk would switch to native winter range. As a result, elk numbers on native winter range would be greater than the estimated 2,900–5,200 under baseline conditions and Alternative 1. The number of elk wintering in the park is less likely to grow, because much of it is covered in deep snow and offers little additional habitat beyond what is used now.

Eliminating hunting on the refuge would allow more elk to use this transitional range, potentially increasing winter use as well. However, eliminat-
ing hunting would also confound the effects of reducing and eventually eliminating supplemental feeding, as elk would see the refuge and parklands as safe zones. Despite this lack of harvest, once supplemental feeding had been phased out, elk numbers on the refuge and in the park would fluctuate more naturally (dependent on weather and predators) and more widely than under current conditions or Alternative 1. Increased mortality would occur primarily during severe winters, and perhaps during above-average winters. During all years, fewer and more widely dispersed elk would remain on the refuge. In the long term, refuge elk would be allowed to “self-regulate” based on numbers that native forage could sustain. Mortality on the refuge and in the park would primarily be due to natural processes such as predation and starvation.

**Elk Numbers in the Jackson Elk Herd**

**Short-term Effects**

Immediate cessation of hunting on the refuge and the elk reduction program in the park would increase numbers in the short term. Because hunting on the refuge and the reduction program in the park together contribute an average of approximately 35% of the total annual herd reductions, the Wyoming Game and Fish Department could have difficulty keeping the Jackson elk herd close to objective during the 10–15 year period when supplemental feeding was being gradually phased out. As reductions in the frequency of supplemental feeding fostered greater reliance on native vegetation, elk numbers on the refuge would gradually decrease. Phasing out feeding near the end of the 10–15 year period would result in minor declines (up to 20%) of elk wintering on the refuge and negligible to minor declines in the Jackson elk herd.

Eliminating hunting and the elk reduction program would also have immediate effects on summing elk. To the extent that elk would winter on the refuge and in the park while supplemental feeding continued, the number of elk in the herd and on summer range would increase. A large portion of these elk would spend the summer in the park, and increases in this segment of the herd could occur. Elk in other segments might be subject to hunting on their return to the refuge in the winter (the Gros Ventre segment) or travel through the park to the refuge and avoid being hunted (the Teton Wilderness and Yellowstone segments).

**Long-term Effects**

In the long term elk numbers in the Jackson herd under Alternative 2 would be lower than under baseline conditions and Alternative 1. Elk on the refuge could drop to 1,200, and total herd numbers would range from an estimated 8,100 to 11,000. This range was calculated through combining known minimum averages for various portions of the herd (e.g., 1,200 on the refuge, 2,500 on the Gros Ventre feedgrounds, and 4,400 on native winter range).

Factors decreasing elk numbers in the long term would include the elimination of supplemental feeding, cultivation, and irrigation on the refuge, and forage competition with bison. At the same time, other aspects of Alternative 2 would increase elk numbers. Eliminating the elk reduction program in the park and hunting on the refuge would decrease fall mortality, contribute to higher total herd numbers, and to some extent decrease mortality due to forage shortages during severe winters. In addition, increased forage created through the Jackson Interagency Habitat Initiative, a joint effort by the U.S. Forest Service, the Wyoming Game and Fish Department, and other partners, would reduce winter mortality.

When the Jackson elk herd was at objective (baseline levels), elk numbers wintering in the park would average approximately 360, with a range of 140 to 860. Winter severity would continue to influence elk numbers, with more elk able to winter in the park during average or milder-than-average winters when there is less snow and more available forage. During winters with accessible forage, park elk numbers could increase compared to historical levels due to the elimination of hunting on the refuge and in the park. No hunting would increase the attraction of this transitional range and the length of time elk would remain there. Habitat improvement efforts in Bridger-Teton National Forest would also increase the number of elk on native winter range. In addition, if concerted efforts were made to actively restore migrations, elk numbers on native winter range would be greatly increased.
Distribution and Movements of Elk

Short-term Effects

Eliminating hunting on the refuge and the elk reduction program in the park, as well as changes in cultivation, irrigation, and prescribed burning on the refuge, habitat enhancements outside the refuge and the park, and the gradual elimination of supplemental feeding would all influence the distribution and movement of elk.

Eliminating hunting on the refuge and the elk reduction program in the park would increase elk movements and distribution in the fall and probably in the winter as well. In addition to spending time in traditional non-hunt areas, elk would extend time spent in newly designated non-hunt areas. Supplemental feeding would continue to attract elk to feedgrounds and adjacent areas until there were substantial reductions in frequency of supplemental feeding years. During non-feeding years, elk movements and distribution would increase due to reliance on native forage, and wider distribution would become relatively more common.

As supplemental feeding was phased out, the distribution of elk to native winter range would increase. This is in part because adults would require food elsewhere, but also because calves would become accustomed to feeding on native forage and would be progressively less likely to ever be exposed to supplemental feeding. Currently, as elk get older, they stand a greater and greater chance of discovering a feedground or learning about locations by following experienced individuals. Once fed, typically they return year after year. After several non-feeding years occur back to back, proportionally more elk would be unaware of feedgrounds and would remain on native winter range, even during years when supplemental food was provided (B. L. Smith, pers. comm. 2003).

Prescribed fire on the refuge has helped create more nutritious grasses for elk, and its elimination in this alternative would result in negligible changes to distribution on the refuge. Converting cultivated fields to native vegetation would also provide less forage than is currently the case, resulting in more widespread dispersion of elk onto native winter range.

Distribution would be further encouraged by forage enhancements in the Gros Ventre River drainage and Buffalo Valley that would be undertaken by the Wyoming Game and Fish Department, the U.S. Forest Service, and other partners as part of this alternative. These enhancements would begin in the short term and would provide additional forage, attract elk to improved areas, and allow more elk to subsist on native range. Some elk could wander farther into the Gros Ventre River drainage, discover WGFD feedgrounds, and increase densities there. If attempts to acquire conservation easements were successful, these procurements would prevent further loss of habitat to development, providing elk with continuing sources of good habitat and promoting wider distribution.

Long-term Effects

The actions described above to feeding, forage, and hunting, as well as elimination of the park elk reduction program, would continue to influence elk movements and distribution in the long term.

Based on modeled estimates (Hobbs et al. 2003), the refuge could support between 1,200 and 6,000 elk without any cultivation or supplemental feeding depending on the severity of winter and other factors. At the high end of the range, elk numbers would approximate current conditions, although because feedlines would disappear, densities and distribution would change. Short-duration feedline concentrations are currently approximately 500 elk per acre. Major declines in densities compared to Alternative 1 would occur when elk numbers are at the low end of the range. On average across the refuge and assuming an even distribution, densities would be decreased to a moderate (35%) degree, 0.32 elk per acre compared to 0.51 elk per acre under baseline conditions. Because elk would not distribute evenly, these numbers should be used only for comparing alternatives, rather than as absolutes.

In addition to causing elk to redistribute on the refuge itself, eliminating supplemental feeding on the refuge would increase elk movements and distribution across native winter range throughout the analysis area. Results of modeling (Hobbs et al. 2003) indicate that elk could winter in areas such as the Gros Ventre River drainage, south of Jackson in the Snake River Canyon, and in lower
portions of Hoback Canyon. Feedgrounds in these areas could stop many elk from moving farther. It is possible that elk might also venture over geographic divides in search of better winter range, as they have been recorded doing in areas of Colorado. In several spots in Colorado elk routinely cross the divide at elevations from 9,000 to 12,000 feet as part of their migration to winter or summer range (Larkins 1997). The divide between the Gros Ventre and Green River basins is 9,000–10,000 feet in elevation (Hinshaw 1989) and may be similarly passable. A wildlife fence currently limits movements to the west and south of the refuge.

More elk might winter in the Buffalo Valley area, and many would use areas immediately to the east of the refuge and the Gros Ventre River drainage; some elk could discover and join the Gros Ventre feedgrounds, inflating traditional numbers at those sites and potentially causing changes from current distribution if many elk did this. Other elk might move to nearby areas in the southern part of the park and winter on south-facing hills or other areas with forage available due to less snow cover. More elk would also venture onto private lands.

The potential impact to elk summering in various locations was analyzed using two possible scenarios from studies conducted on elk using the refuge in the winter. The first is from an analysis of radio-collared elk studied in 1978–82, which indicated about half (48%) of elk wintering on the refuge spent the summer inside Grand Teton National Park. The remainder summered in Yellowstone National Park (28%), the Teton Wilderness (12%), and the Gros Ventre River drainage (12%) (Smith and Robbins 1994). The two scenarios analyzed bracket this range; one assumes about one-third of elk wintering in the refuge would summer in the park, and the other assumes about one-half would do so.

Assuming the park segment comprised approximately 50% of the refuge wintering herd, between 600 and 3,000 elk would summer in the park, a minor to major decrease compared to numbers under Alternative 1. Elk numbers in the other three segments would experience minor decreases to negligible increases. If the park segment represented one-third of the refuge herd size, elk numbers in the park would be reduced to between 400 and 2,000, a moderate to major decrease. Under this scenario, elk numbers in the other three segments would experience minor decreases to negligible increases.

Because they migrate only a short distance to the refuge for the winter, elk that traditionally summer in Grand Teton National Park (the Grand Teton segment) would be less likely to discover adequate winter range than other segments and would continue to seek out the refuge. Elk in the other segments could have more success in finding winter range during their migration because they cover more potential habitat along their migration. Because the park offers sanctuary from hunting, additional elk could winter here or in the currently hunted northern end of the refuge in this alternative.

The forage enhancements described above would also provide additional winter range for elk in the long term, with resulting increases in the scope of their distribution. It is possible that elk could migrate to the Green River basin. However, there are obstacles to migration, including landowner intolerance. In addition, livestock feeding operations and WGFD feedgrounds lie along the migration route, and it is likely that elk would go no farther than the feedgrounds should they encounter them. Over time many elk that now winter on the refuge could find the Gros Ventre feedgrounds, greatly increasing numbers and impacts in that area. Working with private landowners to increase tolerance of elk and concerted agency efforts could potentially foster migration.

Elk Behavior, Social Interactions, and Nutrition

Short-term Effects

Converting cultivated areas on the refuge to native vegetation, and gradually reducing years of supplemental feeding on the refuge under Alternative 2, would affect elk behavior, social interactions, and nutrition. Feedline behavior and competitive social interactions on the refuge would occur only in feeding years.

Because the method of reducing supplemental feeding would eliminate winter feeding first in the mildest winters, there would be relatively little snow cover and vegetation would be accessible.
Impacts on the Jackson Elk Herd: Impacts of the Alternatives — Alternative 2

Nutrition would remain high, and elk would be negligibly affected by the lack of feeding in these years. Ration or pellet composition might need to be changed to allow for later initiation of supplemental feeding during these years. A higher fiber formula as recommended by Baker and Hobbs (1985) for mule deer could be one possibility. Initiation of supplemental feeding would be based on assessments of forage utilization (jointly done by WGFD and NER personnel) and potentially on the January 1 index of winter severity calculations for elk (Farnes, Heydon, and Hansen 1999).

As supplemental feeding became less frequent and cultivated fields were converted to native vegetation, elk would compete for native forage during increasingly severe winters, and nutrition would be decreased. Total herbaceous forage available on the refuge would be lower by a minor amount than under baseline conditions and short-term conditions under Alternative 1. However, elk numbers would eventually decrease on the refuge, and individual elk would be able to gain higher levels of nutrition from vegetation than if the population numbers continued at levels similar to baseline conditions and Alternative 1. Lower densities would also mean fewer cases of psoroptic scabies, which contributes to nutritional stress in elk (Thorne et al. 2002).

**Long-term Effects**

Competition among elk and between elk and bison for forage, and displacement of elk by bison in transitional and winter habitat would be less severe under this alternative than in the long term under Alternative 1. During shortages of native forage, aggressive social interactions involving competition for food with other elk and with bison could increase.

Localized competition with bison for standing forage would occur despite fewer bison on the refuge under this alternative, and elk might move to areas with less desirable forage in order to avoid conflicts with bison. In general, however, broader distributions of elk and bison would diminish competition between the two species.

Nutritional status under Alternative 2 would be similar to that in elk populations that are not food-supplemented. Elk are adapted to survive severe winters and can sustain energetic debt and weight loss of up to 25% during more severe winters (Wisdom and Cook 2002). Other known adaptations in ungulates include thick winter fur, metabolism reduction by nearly one-third, behavioral adaptations (bedding down for long periods during severe weather), and great reliance on stored body fat (Mitchell, McCowan, and Nicholson 1976; Mautz 1978). Although some elk could die during above-average (i.e., more severe) winters because of decreased nutrition and body condition, eventually the number of elk would decrease and food might be more available. Low numbers of elk on the refuge might be able to maintain good nutritional levels on native forage. Implementing Alternative 2 would result in more malnutrition in severe winters and moderate to major increases in mortality in severe winters compared to baseline levels.

Less forage on the refuge could be partially offset by the greater long-term palatability of some native species (Brock, pers. comm. 2003) during years when below-average and average snow depths allow access to these bunch grasses. Another factor that would help offset nutritional deficiencies is the effort agencies would make to enhance the quality and quantity of forage in Bridger-Teton National Forest and Buffalo Valley.

**Disease Prevalence and Transmission**

**Bovine Brucellosis**

*Prevalence in Herd — Under Alternative 2* prevalence for brucellosis in the refuge portion of the Jackson elk herd would likely remain unchanged from current levels in the short term. In the long term, elk density on the refuge would be reduced as the supplemental feeding program was phased out, elk numbers on the refuge would be reduced to 1,200–6,000 animals, and elk would be more widely distributed across native forage. In addition, if obstacles could be removed, it is possible that migration to winter range outside Jackson Hole could be theoretically reestablished (see “Distribution and Movements of Elk: Long-term Effects”). In the absence of a supplemental feeding program, brucellosis prevalence in elk is just 1%–3% (Rhyan et al. 1997; Ferrari and Garrott 2002) and less in some locations (Smith and Roffe 1994). It appears that this low prevalence in elk herds that do not use feedgrounds is maintained by contact with other elk or bison from herds on
feedgrounds. Returning to densities more typical of natural populations would result in a much lower risk of contact with aborted fetuses and a major reduction in long-term prevalence rates that would approach those of other elk populations that are not fed during winter. For the entire Jackson herd (of which the refuge elk are a portion) there would only be a moderate long-term reduction in prevalence because approximately 2,500 elk would continue to be fed on the state-operated Gros Ventre feedgrounds. Elk numbers would likely be higher than 2,500, and possibly much higher if many refuge elk dispersed to the Gros Ventre River drainage and found those feedgrounds.

Transmission among Elk — The chance of brucellosis transmission among elk would drop with decreasing density and a lower chance of contact among elk and contaminated fetuses or birth sites. In the short term the chance of transmission would be reduced by a moderate amount (Disease Expert Meeting 2002). However, as elk learned new movement and distribution patterns, a major decrease would be likely. A similar, minor to moderate reduction in transmission among elk in the entire herd unit would be likely.

Transmission from Bison to Elk — There would be a major reduction in transmission of brucellosis from bison to elk on the refuge for four reasons: (1) numbers of bison and elk would be greatly reduced compared to Alternative 1, (2) the supplemental feeding program would be eliminated and would reduce contact between elk and bison, (3) brucellosis prevalence in the bison herd would be decreased, and (4) fewer abortions would result from reduced prevalence. In the absence of the supplemental feeding program, elk and bison might still co-mingle to some degree on the refuge, but they would not be as concentrated as they would be on feedlines. In areas where both elk and bison are present and there is no feeding program, interspecies transmission is low (Ferrari and Garrott 2002).

Septicemic Pasteurellosis

Because the epidemiology of this disease in elk is poorly understood (B. L. Smith 2001), impacts from the alternatives are discussed in relative terms. Potential impacts on prevalence would be lowest under alternatives that reduce the number of elk on the refuge and reduce the supplemental feeding program, so potential impacts are expected to be lowest under Alternatives 2, 3, and 6. Potential impacts under Alternative 2 would be expected to be similar to Alternatives 3 and 6. For more detailed discussion, see the corresponding section for elk under “Disease Prevalence and Transmission” for the impacts of Alternative 1.

Necrotic Stomatitis and Footrot

An increased incidence of necrotic stomatitis in the Jackson elk herd could occur if sufficient high quality forage was not available and elk were forced to use poor-quality forage such as coarse woody vegetation. Prevalence of necrotic stomatitis could increase by a negligible to minor degree depending on winter severity under Alternative 2 compared to Alternative 1 because relatively high numbers of elk (up to 6,000) could remain on the refuge with no forage enhancements or supplemental feeding. However, under baseline conditions excessive use of coarse woody vegetation occurs with little prevalence of necrotic stomatitis. Adverse impacts on mortality, production, and recruitment in the Jackson elk herd would be the same as the impacts on prevalence (negligible to moderate depending on winter severity) under Alternative 2 compared to Alternative 1.

Necrotic stomatitis is not transmissible; hence, transmission among elk would not be a factor under any of the management alternatives.

Prevalence of footrot would be lowest under Alternative 2 (and 6) because supplemental feeding would be eliminated.

Psoroptic Scabies

Supplemental feeding results in direct contact between elk, increasing the chance for transmission of psoroptic mites among elk. Prevalence of psoroptic scabies in the Jackson elk herd would decline where winter feeding was reduced. For this reason, prevalence of psoroptic scabies in the elk herd under Alternative 2 (similar to Alternatives 3, 4, and 6) would decrease by a negligible to minor amount compared to Alternative 1 due to the reduction in the winter feeding program and the number of elk.
Helminths and Lungworms

Lungworm transmission and prevalence in the elk herd would be lowest under Alternative 2 (and Alternative 6) because supplemental feeding would be reduced on the refuge in the short term, and eliminated in the long term, and lower numbers of elk would winter on the refuge compared to Alternative 1. Impacts would be less than under all other alternatives. Lungworm transmission among elk and prevalence in the elk herd would be higher under Alternatives 3 and 4, and would be greatest under Alternatives 1 and 5 because winter feeding would occur nearly every year and high elk numbers would be maintained.

Bovine Tuberculosis and Paratuberculosis

Bovine tuberculosis and bovine paratuberculosis are not present in the Jackson elk herd. Although analyzed here, bovine paratuberculosis has only been reported sporadically in elk and should be considered primarily a disease of bison (Roffe, pers. comm. 2005). The relative risk among the alternatives that either of these diseases would become established would be lowest under Alternative 2 because the supplemental feeding program would be eliminated.

If bovine tuberculosis or bovine paratuberculosis infected the Jackson elk herd in the short term before the elimination of winter feeding, the potential for transmission and therefore potential prevalence would be much lower under Alternative 2 than under Alternative 1. In the short term prevalence would likely be lower by a moderate amount compared to Alternative 1 as locally high densities of elk in western portions of the park and elsewhere in the Jackson herd unit might provide focal points of transmission (B. L. Smith, pers. comm. 2003). In the long term both the potential for transmission and prevalence would be lower by a major amount than under Alternative 1. Because many fewer bison would use the refuge under this alternative, both the potential for transmission of these diseases from bison to elk, and prevalence in bison in the analysis area, would be reduced by a major amount.

Malignant Catarrhal Fever

The risk of elk or bison that now feed on the refuge contracting malignant catarrhal fever would be greatest under Alternative 2 because elk and bison would disperse more widely and would have a greater chance of coming into contact with domestic sheep herds and potentially contracting the virus that causes malignant catarrhal fever. However, this would be offset by decreases in numbers and density of both elk and bison compared to Alternative 1.

Overall, potential for impacts from this virus would be lowest under Alternatives 2, 3, and 6 because elk numbers would be reduced (1,200–6,000 under Alternative 2; 1,000–2,000 under Alternative 3; 2,400–3,200 under Alternative 6) in the long term, and supplemental feeding would not occur under Alternatives 2 and 6. Even though winter feeding would occur in severe winters under Alternative 3, the potential for impacts would be less than under Alternatives 1, 4, and 5.

Chronic Wasting Disease

Based on presumed transmission and prevalence of chronic wasting disease as described in Chapter 3 (see page 136) prevalence under Alternative 2 (and Alternative 6) would increase slowly compared to alternatives in which supplemental feeding, ungulate concentrations, and a greater likelihood of environmental contamination in localized areas would occur (Alternatives 1 and 5; and Alternatives 3 and 4 to a lesser extent). The risk of chronic wasting disease being introduced into the Jackson elk herd would be highest under alternatives with the highest elk numbers (Alternatives 1 and 5, somewhat less under Alternative 4, and lower under Alternative 6, 2, and 3) because a larger herd would result in more elk dispersing into summer range and some elk wandering beyond the designated herd unit area, increasing the potential for contracting the disease.

Under Alternative 2 if migration to the Green River basin occurred, there would be a moderate increase in the risk of chronic wasting disease becoming established in the Jackson elk herd compared to Alternative 1. Some contact between Jackson elk and adjacent herds in the Green River and Wind River drainages presently occurs (B. L. Smith, pers. comm. 2003). This risk would be similar to but greater than that under Alternative 3. If this disease became established in the Jackson elk herd, prevalence would ultimately lie within
the range seen in free-ranging and confined elk (see discussion under Alternative 1).

Despite unknowns identified above, the alternatives were ranked for the rate of transmission and prevalence of chronic wasting disease based on two primary factors, (1) supplemental feeding frequency and duration, and (2) the number of elk on the refuge. High concentrations due to winter feeding would not occur under Alternative 2 (or Alternative 6) after winter feeding was phased out, and prevalence of chronic wasting disease under these alternatives would likely be lower than under all other alternatives (see Table 4-6).

Because surveillance would be accomplished through sampling harvested elk, agency removals might be necessary under Alternative 2 to contribute to WGFD surveillance goals.

Calving, Age and Sex Ratios, and Recruitment

Short-term Effects

Sex and age ratios in portions of the Jackson elk herd would begin to change in the short term because elk hunting on the refuge and the elk reduction program in the park would not occur. In these unhunted portions of the herd, sex ratios would start to resemble those found in unhunted elk populations (about 33 branch-antlered bulls and 17 spikes per 100 cows; DeSimone, Vore, and Carlsen 1993) and in unhunted European red deer populations (about 50 bulls per 100 cows; Mitchell, Staines, and Welch 1977). Bull-to-cow ratios would become higher than those recorded for the Jackson elk herd in winter 2004 (33 bulls per 100 cows, comprised of 25 branch-antlered bulls and about 8 spikes per 100 cows). The prime-aged male cohort would become a larger proportion of elk in these areas because hunters would no longer be removing them at a higher rate than other sex or age categories.

Impacts on production and recruitment rates for the refuge portion of the Jackson elk herd associated with brucellosis would not be expected to change in the short term.

Long-term Effects

Sex and age ratios in non-hunted parts of the herd would be more similar to those in non-hunted elk populations, as described above. Reducing calf loss due to brucellosis would represent a negligible increase (less than 1%) in Jackson elk herd production and recruitment.

Disease might also affect production and recruitment. Those diseases that spread by means of contact with infected elk or bison, such as septi-cemic pasteurellosis, and bovine paratuberculosis and tuberculosis, would run the lowest risk of spread in alternatives with lower densities and wider distribution, such as Alternative 2. They would therefore have the least impact on production and recruitment. Under Alternative 2 potential production losses from bovine tuberculosis or paratuberculosis would be reduced by a moderate amount over time compared to potential losses under Alternative 1. Because prevalence would likely be low if infection occurred, and because losses in calf production under the latter would be negligible, potential calf production could be increased by a negligible amount under Alternative 2. The absolute impact of these diseases on production in the herd would be low. Impacts on production and recruitment from septicemic pasteurellosis under Alternative 2 (and Alternative 6) would be similar to those under Alternative 3 and lower than under all other alternatives.

Adverse impacts on production and recruitment from necrotic stomatitis in the Jackson elk herd would be similar to its prevalence, that is, negligible to moderate depending on winter severity, under Alternative 2 compared to Alternative 1.

The negligible decrease in prevalence of psoroptic scabies expected under Alternative 2, which would be similar to impacts under Alternatives 3, 4, and 6, would not likely affect production and recruitment of the Jackson elk herd in the long term. Adult bull mortality from psoroptic scabies would decrease negligibly under Alternative 2 compared to Alternative 1 due to the reduction in the winter feeding program and the reduced number of elk in the herd.

There are no impacts at present from chronic wasting disease. If this disease became established in Jackson Hole, it would affect productivity and, if mortality was additive, could affect recruitment. Numbers of calves produced each year could decline with a smaller population and fewer adult females to produce calves. Chronic wasting
disease may affect older animals to a greater extent than it would younger animals. This is also true of bovine paratuberculosis and tuberculosis.

Impacts on calving and ratios from chronic wasting disease would be caused indirectly through changes in mortality, the level of which would depend on prevalence in the herd. Experts believe prevalence would lie between levels found in free-ranging and confined elk (4% on average and up to 59% or higher, respectively). Relative impacts on production and recruitment under Alternative 2 (and Alternative 6) would be lower than potential impacts under all other alternatives (see Table 4-6).

**Mortality**

*Short-term Effects*

Elk mortality would be lower in the short term, at least during the early years of Alternative 2, compared to baseline conditions and Alternative 1 due to the elimination of the refuge elk hunt and the park elk reduction program. Decreases in mortality would primarily affect elk wintering on the refuge.

Currently, elk harvesting on the refuge and the elk reduction program in the park are responsible for about 34%–35% of the total harvest of the Jackson elk herd, with the park contributing about 23%, the refuge about 11%, and other areas 67% of total herd harvest (WGFD 1989–2003). When hunting on the refuge and the elk herd re-duction program in the park stopped, more elk might move into protected areas, that is, the park and the refuge.

Winter mortality would gradually increase on the refuge as supplemental feeding was phased out, especially if the fence was maintained at the southern and southwestern sides of the refuge. Because the number of elk and competition for what could be scarce food resources on native winter range would increase, mortality in the herd would also increase. Elk from the park segment would primarily be affected.

Some elk that otherwise would have been attracted to supplemental feed on the refuge might instead move south of the park to private lands, where they could cause depredation and possibly increase the risk of disease transmission to cattle. Elk from other herd segments would likely find wintering areas to the northeast and east of the refuge, including the Gros Ventre feedgrounds.

*Long-term Effects*

In the long term the lack of supplemental feeding or cultivated forage on the refuge would increase mortality, but cessation of hunting would continue to reduce it. Because supplemental feeding, cultivation, and irrigation on the refuge would have been phased out after the initial 10–15 years, elk would subsist on natural forage alone. In the long term winter mortality would be higher than under baseline conditions and under Alternative 1, ranging from 1% to about 20% of elk formerly fed on the refuge. Levels would reflect winter severity, ranging from very low during mild winters to high during severe winters (B. L. Smith, pers. comm. 2002; Hobbs et al. 2003). The estimated range for mortality is similar to mortality in Yellowstone National Park’s northern elk herd from March 2000 to February 2003 (S. B. Evans and L. D. Mech, University of Minnesota, unpubl. data). Preliminary results from 91 radio-collared animals indicated that mean annual mortality averaged 17% and ranged from 7% to 22%. Elk that wintered outside the park, where they were exposed to hunting, and elk that wintered primarily inside the park where no hunting occurred but wolf densities and use was higher, did not experience significantly different mortality rates.

As elk ventured further from the refuge in search of native forage, they would be more likely to occupy private lands, where they could depredate hay crops, or mingle with livestock. In those cases management action by WGFD personnel could be required and could include depredation hunts, agency removal, or relocation of elk. The Wyoming Game and Fish Department also anticipates increased conflict between elk and non-agricultural landowners, with depredations to ornamental shrubbery, horse hay, and increased vehicle collisions in and around subdivisions (Holz, pers. comm. 2003).

Although more predation would be expected under Alternative 2, this increase would likely be compensatory. More elk would experience some degree of energetic debt, relying on body fat and lean body mass to survive winter. Severe winters
would cause lower physical condition in some, making them easier prey. Calves, mature bulls already stressed physiologically from rut activities, and older animals would be the most likely cohorts to experience higher predation.

In the long term mortality from septicemic pasteurellosis under Alternative 2 would be similar to that under Alternatives 3 and 6 and lower than under all other alternatives. Necrotic stomatitis is rare on the refuge now, and it is fatal only in serious cases when infections become chronic and the animals lose teeth and eventually die of starvation. Although prevalence of this disease could increase by a negligible to minor amount (see “Disease Prevalence and Transmission” above), mortality related to it would not likely increase beyond negligible levels in the long term. Outbreaks of footrot could occasionally occur during feeding years, particularly when compacted, icy snow conditions and high elk densities on feedgrounds coincide. Associated mortality would be lowest under Alternative 2 (and Alternative 6) because supplemental feeding would be eliminated.

Adult bull mortality from psoroptic scabies would decrease negligibly under Alternative 2 due to the reduced number of elk in the refuge herd as well as lower elk concentrations stemming from the elimination of the refuge feeding program.

Alternative 2 would potentially result in a moderate reduction in mortality caused by bovine tuberculosis compared to Alternative 1, because prevalence and thus the number of clinical cases would be reduced by a moderate amount.

Chronic wasting disease is generally fatal, and models for deer predict eventual extirpation of affected populations (Gross and Miller 2001). This means it can have population-wide lethal effects and lead to population decline, although whether whole populations would become extinct or not is unknown. Recent estimates of chronic wasting disease prevalence in affected free-ranging Wyoming herds were about 4% on average (2.3%–9.6%) in elk and 6.5% (4%–18%) in deer (WGFD, unpubl. data). The impact on mortality in the herd would be directly related to prevalence. Relative mortality among the alternatives would therefore likely parallel rankings described above under “Disease Prevalence and Transmission,” i.e., it would likely be lowest under Alternatives 2 and 6 compared to all other alternatives (see Table 4-6), and Alternative 3 would be next lowest.

Most conceptual models suggest that non-fed populations (e.g., the elk herd under Alternatives 2 and 6) would likely survive at higher numbers and/or for a longer time than would fed populations, but in the worst case might be about the same as fed populations (Roffe, pers. comm. 2004).

Data on free-ranging elk have shown a very slow rate of increase in prevalence of the disease, while data from game farms and research facilities have suggested that fairly rapid spread of infection is possible (Williams and Young 1980; M. W. Miller, Wild, and Williams 1998; M. W. Miller et al. 2000). Given these factors, it is assumed that alternatives with less supplemental feeding (e.g., fewer years of concentrating elk and contaminating the environment) would decrease mortality in the long term. These differences might only be apparent with large-scale changes, as it is considered unlikely that even lowering the number of supplemental feeding years by half would substantially alter the high potential for transmission through environmental contamination.

Health, Sustainability, and Naturalness

Short-term Effects

The health and sustainability of the Jackson elk herd would increase gradually as supplemental feeding was phased out and there was greater reliance on natural forage. Lower elk numbers and concentrations that would begin to occur later in the short term would result in lower disease prevalence and transmission of current diseases such as brucellosis as well as the risk of contracting or spreading any non-endemic infectious disease.

Naturalness would increase gradually in the short term under Alternative 2 as elk increasingly dispersed according to the distribution of available forage on native range. Natural phenomena, such as winter weather and predators, would have an increasingly stronger influence on mortality. Numbers, density, sex and age ratios, potential for disease transmission, and behavior would all much more closely approximate elk populations under natural conditions as supplemental feeding de-
creased. Human effects would occur at a much reduced level through some winter feeding, agency removals, and vehicle collisions, but these would decline as elk numbers decreased over time.

Long-term Effects

Health and sustainability under Alternative 2 would be greater than what would occur under all other alternatives, except Alternatives 3 and 6.

Herd health would improve because of increased dispersion of elk and bison as supplemental feeding was discontinued on the refuge and forage improvements by the U.S. Forest Service, the Wyoming Game and Fish Department, and other partners were made. Brucellosis seroprevalence and transmission would be reduced compared to Alternative 1. Transmission risk and the likelihood of major adverse impacts from other diseases would also be lowered. For these reasons, long-term health and sustainability of the elk herd would be highest under Alternative 2 (along with Alternative 6).

Barring the introduction of serious non-endemic disease, the herd would continue to be genetically viable and self-sustaining at lower numbers, although elk numbers could drop substantially if winters of above-average severity and pre-winter drought occurred repeatedly for several consecutive years. As discussed under Alternative 1, an average of about 5,000 elk currently survive annually on native range. This could increase following forage improvements. However, even with these improvements, some mortality in the herd would occur as elk progressively relied on native winter range.

As in the short term, the elk herd would be progressively more subject to the influence of natural factors in the long term under this alternative. Climate and amounts of native forage would be particularly influential on numbers, movements, distribution, and mortality.

Production and recruitment rates, winter mortality, nutritional status, and distribution would also be more natural. Mortality rates among age and sex classes would mimic unfed populations, including higher mortality rates in calves born out of season.

Elk behavior would also become more natural. Competitive social interactions associated with feedlines and displacement of elk would decrease because there would be fewer elk and bison, wider ungulate distribution, and lower densities.

Effects of hunting would continue to be negligible and could be reduced in the long term if herd size and distribution decreased substantially. Harvest would have a minimal influence on the sex ratio because hunting would continue to occur outside the boundaries of the park and the refuge and it is expected that only a small number would be killed annually. Increases in mortality due to vehicle accidents or agency removals as a result of wider distribution would be negligible to minor, compared to baseline conditions and Alternative 1.

Of all alternatives, Alternative 2 (and Alternative 6) would result in the highest level of naturalness in the elk herd.

Conclusion

In the long term under Alternative 2 the Jackson elk herd would consist of an estimated 8,100–11,000 elk. The total herd size would fluctuate, decreasing during severe winters to perhaps as low as 8,000 (approximately) but rebounding during other years. The herd would be smaller than under baseline conditions and Alternative 1 in some years, similar in size to Alternatives 3 and 6, and smaller than Alternatives 4 and 5. In the long term this alternative would lower the number of elk that winter on the refuge and summer in the park. Wintering elk numbers on the refuge would decrease to between 1,200 and 6,000. More elk would forage on native winter range in Bridger-Teton National Forest outside the refuge and the park.

Wintering elk would disperse in search of natural forage as supplemental feeding stopped over time. Increased mortality would result initially and as more and more elk competed for natural vegetation. When supplemental feeding stopped, the herd would be more responsive to natural conditions, and winter mortality would fluctuate with winter severity, precipitation regimes, and standing forage. Recruitment and annual survival would decrease compared to Alternative 1 and would be closer to levels found in non-fed populations in similar environments. The above impacts
would occur to a lesser extent if large numbers of dispersing elk discovered the Gros Ventre feedgrounds and continued to be fed in winter.

Calf production in the long term could increase during consecutive years of mild weather due to reduced brucellosis abortions, lower elk densities, and more available native forage.

Ceasing harvest on the refuge and in the park could imbalance herd segments. However, increases in mortality caused by greater reliance on native vegetation and predation would offset the lack of harvest and reduce differences in herd segment mortality levels. Harvest mortality in other areas could decrease overall as more elk might avoid hunters by remaining within the park and on the refuge.

The risk of a non-endemic infectious disease quickly spreading through the elk population after being introduced into the herd would be lowest under Alternative 2 (along with Alternative 6). Low risk would be due to the elimination of the nearly annual supplemental feeding program and the reduction in bison and elk numbers. Alternative 2 (along with Alternative 6) would also have the lowest risk of such a disease having major adverse impacts to survival and population sustainability. The prevalence of brucellosis in the Jackson elk herd would be moderately lower than under Alternative 1.

Alternative 2 (along with Alternative 6) would result in higher levels of long-term health, sustainability, and naturalness in the Jackson elk herd than what would occur under Alternatives 1, 3, 4, and 5.

Barring the introduction of serious non-endemic disease, Alternative 2 would not impair the elk population in the park. Alternative 2 (along with Alternative 6) would have the lowest potential for impairment. Attempts to maintain low natural densities of elk and bison would decrease adverse effects.

**ALTERNATIVE 3**

This alternative would actively manage elk and bison to keep numbers at designated levels (1,000–2,000 elk, approximately 1,000 bison) by minimizing supplemental feeding and using habitat improvement and changed hunting regimes to encourage elk and bison to disperse. Feeding would be reduced over time so that after 10 to 15 years supplemental feeding would be used only in the most severe winters. Hunting on the refuge and the elk reduction program in the park would be key to maintaining numbers at their desired levels.

**Analysis**

**Numbers of Elk Wintering on the National Elk Refuge and on Native Winter Range**

**Short-term Effects**

During the initial 10 to 15 years of plan implementation, elk numbers on the refuge would be reduced as supplemental feeding was gradually reduced, as competition for forage with bison continued, and as elk began to forage on native range in other areas. Elk harvest, especially the Grand Teton segment, would be increased initially to decrease the number of elk wintering on the refuge. The combination of this increased harvest, enhanced winter range outside the refuge, and decreased supplemental feeding would gradually result in fewer elk on the refuge. Elk mortality would primarily be related to hunter harvest, as only negligible increases in non-harvest mortality of up to 3%–4% per year would be expected. Within 10–15 years it is anticipated that the number of elk on the refuge would be between 1,000 and 2,000, the population objective under this alternative.

Conversely, the number of elk would gradually increase on native range as supplementing feeding was slowly reduced and eliminated in all but the most severe winters. Elk numbers on native winter range would increase during non-feeding years and initially remain relatively similar to existing conditions (4,400–7,900 elk) during years with supplemental feeding. However, as progressively more elk wintered on native range, knowledge among the herd of the refuge feedground location would decline and the number during feeding years would drop. It is possible that a negligible increase in the number of elk occupying habitat in the park would occur during mild winters.

The recovery of woody vegetation and prevalence of brucellosis would help in deciding whether the
Elk herd had been sufficiently reduced. If woody vegetation and brucellosis objectives appeared reachable when elk numbers were still higher than objective, the number of elk on the refuge would be allowed to remain at those levels. However, if 1,000–2,000 elk on the refuge maintained unacceptable levels of brucellosis and adversely impacted woody vegetation, then refuge elk numbers could be further decreased.

Feeding would be eliminated first in milder-than-average winters, then in average winters, and then in above-average winters. Ultimately, feeding would take place only in severe winters, an estimated 2 of every 10 years depending on snow and weather conditions. Fewer years of feeding would cause elk wintering on the refuge to increase their reliance on native winter range during non-feeding years. Increased dispersal and closure of hunt areas on the northern portion of the refuge and the southern part of the park would encourage elk to stay in those areas during transition and winter months rather than move to the refuge feedgrounds.

Option A under this alternative would not change irrigation and cultivation practices on the refuge from current management. As elk numbers decreased, continued production of forage would better sustain the 1,000–2,000 elk and approximately 1,000 bison remaining on the refuge. This also means that, when winters are severe and supplemental feeding was required, the number of feeding days would be reduced compared to current conditions. Option B would result in the return of cultivated forage to native range.

**Long-term Effects**

Elk numbers on native winter range would increase, and those on the refuge would decrease in the long term.

As in the short term, fewer elk on the refuge would primarily be maintained through hunter harvest, particularly of the Grand Teton segment. Other factors that would contribute to maintaining refuge numbers at about 1,000–2,000 include winter feeding only in severe winters, reliance on available standing forage in most years, reliance on native vegetation (Option B of Alternative 3), improved habitat conditions in Bridger-Teton National Forest, and competition with about 1,000 bison. As stated previously, the objective of 1,000–2,000 elk on the refuge would depend on the degree to which disease prevalence and restoration of woody vegetation was achieved and the ability to increase harvest levels for the park segment.

Elk would disperse to native winter range in search of food. As progressively more had no memory of the refuge feedgrounds, numbers would continue to fall and eventually stabilize at 1,000–2,000. Numbers on native winter range would be greater than the estimated 4,400–7,900 under existing conditions, and greater than the 2,900–5,200 under baseline conditions and Alternative 1. Closing some areas of the refuge to hunting, along with portions of the park to the elk reduction program, as well as improvements in habitat quality in Bridger-Teton National Forest, would also help disperse elk and would contribute to larger numbers of elk on native winter range. Some elk would continue to return to the refuge to winter on restored native range or on standing cultivated forage.

Irrigation and cultivation practices on the refuge would continue to affect elk numbers. In Option A these practices would be the same as under Alternative 1 and would not change amounts of forage produced by farming practices. With only 1,000–2,000 elk wintering on the refuge, present forage production would better sustain elk, along with approximately 1,000 bison, during average and above-average winters than under baseline conditions and under Alternative 1 (5,000–7,500..
elk and 1,000 bison, with the number of bison continuing to increase). Option B would be the same as under Alternative 2, in which cultivation and irrigation would be eliminated and 2,400 acres of cultivated fields would be converted to native vegetation. This option would produce less forage, and fewer elk would subsist on amounts of available native vegetation. Modeling by Hobbs et al. (2003) and other work indicate that forage amounts would be adequate for the reduced population of elk and bison remaining on the refuge. Elk numbers on native winter range would be greater than under Option A because supplemental feeding would be eliminated.

When the Jackson elk herd is at objective (baseline levels), elk numbers wintering in the park would average approximately 360, with a range of 140 to 860. Winter severity would continue to influence elk numbers, with more elk able to winter in the park during average or milder-than-average winters.

**Elk Numbers in the Jackson Elk Herd**

**Short-term Effects**

Changes in the number of elk wintering on the refuge would be reflected to an extent in the Jackson elk herd. Greater harvest of elk using the refuge would lower total herd size, but dispersal of elk wintering on the refuge onto improved winter range in Bridger-Teton National Forest and targeted reductions in the Grand Teton segment (which would have the hardest time finding alternative winter range) would help minimize the reduction in other herd segments. Gradually decreasing the frequency and duration of supplemental feeding on the refuge would cause greater reliance on native vegetation and lower elk numbers on the refuge. Many of the elk that would otherwise have used the refuge would disperse to native range beyond refuge boundaries, onto Bridger-Teton National Forest and into the park. Elk numbers in the Jackson elk herd would, on average, decrease over time by a negligible to moderate amount. However, in many years, elk numbers would be at or above the herd objective.

**Long-term Effects**

The total Jackson herd under Alternative 3 would decrease compared to baseline conditions and Alternative 1, to an estimated 7,900 to 11,000, approximately the same size as under Alternative 2. The lower end of this range is a combination of the lowest number of elk estimated on native winter range, on the refuge, and on the Gros Ventre feedgrounds. The upper end of the range would continue to be capped at approximately 11,000 elk by the state’s elk harvest program.

**Distribution and Movements of Elk**

**Short-term Effects**

Aspects of Alternative 3 that would influence elk movements and distribution in the short term include changes in hunting practices, the reduction of supplemental feeding years, and habitat enhancements.

Immediate effects on movements and distribution would stem from increased harvest and changes in hunt areas. Fall, and likely winter, elk distribution would increase because, in addition to spending time in traditional non-hunt areas, elk would increase forage use and time spent in newly designated non-hunt areas such as the northern portion of the refuge and Antelope Flats, the Kelly hayfields, and Blacktail Butte in the park. Some elk could choose to spend more time in transition areas, in potential wintering areas in the park and the northern part of the refuge, and areas eastward.

An early season hunt in either the southern or middle portions of the refuge (or both) would be likely under this alternative. Another option would be to open the southern end of the refuge to visitors instead of a hunt. Either option would help move elk northward where they could be harvested. Either or both of these programs would particularly influence movements and distribution of elk that arrived on the refuge early (i.e., the Grand Teton segment). Some of these elk, if not harvested on their way through hunt areas, might find the newly closed portion of the refuge or closed portions of the park.

For those elk that were successful in reaching the feedlines, winter distribution would remain similar to baseline conditions during the first few years as supplemental feeding continued.
The gradual reduction in supplemental feeding to approximately 2 winters of 10 (depending on the severity of winter weather) would increase dispersal onto surrounding winter range compared to baseline conditions and Alternative 1. Cultivated fields on the refuge would continue to attract elk. In years when snow crusting events made cultivated fields with high forage production inaccessible to elk, mechanical means would be used to increase elk access and extend their use of these areas.

More elk could winter in the Buffalo Valley area, and many would use areas immediately to the east of the refuge and in the Gros Ventre River drainage; some elk could discover and use the Gros Ventre feedgrounds. Other elk could move to nearby areas in the southern part of the park and winter on south-facing hills in other areas with forage available due to less snow cover. In above-average and severe winters more elk could follow the environmental gradient to the refuge, which is at a lower elevation than the park and adjacent national forest lands and therefore would likely have less snow. If elk attempted to move to potential winter range south of Jackson in the Snake River Canyon or in lower portions of the Hoback Canyon, many could be stopped from moving farther by the state feedgrounds in these areas.

Most of the shift in winter distribution would involve elk in the Yellowstone, Teton Wilderness, and Gros Ventre segments, as those in the Grand Teton segment are considered most likely to continue wintering on the refuge.

A negligible amount of prescribed fire on the refuge, as well as in the park, would continue to enhance forage and habitat and attract elk to treated areas, as under baseline conditions and Alternative 1. In addition, the U.S. Forest Service, the Wyoming Game and Fish Department, and other partners would enhance habitat in Bridger-Teton National Forest east of the refuge in the Gros Ventre River basin and in Buffalo Valley, which would increase elk distribution. The Wyoming Game and Fish Department might be able to adjust hunting strategies in order to help elk find and stay on enhanced winter range outside the refuge and park (Kilpatrick, pers. comm. 2003). Increasing distribution and movements potentially could lead to the use of some wintering areas outside Jackson Hole. Success would depend on wide elk distribution, interagency cooperation, and coordination with and cooperation from private landowners. If attempts to acquire conservation easements were successful, further loss of habitat to development would be prevented, providing elk with continuing sources of good habitat and promoting wider distribution.

Under Alternative 3 vaccination for brucellosis would occur if a safe vaccine was developed with a minimum efficacy of 50% for elk and bison. Current vaccine efficacy is estimated at up to 25% for elk and undetermined for bison due to equivocal preliminary research results.

If the vaccine was in biobullet form and delivered by air gun to elk on refuge feedgrounds, elk responses could vary on a daily basis. When elk were vaccinated during 1989–91, small numbers of elk regularly ran from the report of the air gun, but soon returned to feeding (Griffin, pers. comm. 2002). Larger responses, such as the movement of large numbers or all animals away from a particular feeding area might also occur (B. L. Smith, pers. comm. 2002). Because supplemental food would remain available, these larger movements are not expected to last for more than a day for most elk, and impacts would be minor. Conducting vaccinations on an irregular basis (for example, every second or third day) could mean that elk might less readily become accustomed to the activity, and some elk could abandon a particular feedground (Cole, pers. comm. 2002).

Vaccination teams and feed truck drivers would monitor and record elk response daily, and the vaccination program would be adjusted as needed to avoid more serious effects. Most elk are considered likely to return to the feedlines after being disturbed (B. L. Smith, pers. comm. 2003).

Long-term Effects

Lower elk numbers, changes in hunting practices, a gradual reduction in supplemental feeding to about 2 of 10 years, and habitat enhancements on native winter range would influence elk movements and distribution in the long term under Alternative 3 in feeding years. Brucellosis vaccination activities would continue to cause short-duration, negligible to minor increases in elk movements and distribution during delivery as described above. Changes in hunting practices,
including the closure of traditional hunting areas and the opening of new, non-traditional areas, would continue to increase movements and distribution in the long term.

Localized areas of competition with the approximately 1,000 bison wintering on the refuge would alter elk distribution, particularly because of reductions of supplemental feeding and increased reliance on standing forage. This competition could cause elk to move to areas with less desirable forage in order to avoid conflicts with bison. In general, however, overall competition with bison would decrease under Alternative 3 compared to the competition under Alternative 1 with its long-term continued growth of the bison herd. Competition would decrease compared to baseline conditions, in which approximately 5,600 elk and approximately 1,000 bison share the refuge in winter.

Habitat enhancements on and off the refuge and the use of prescribed fire on the refuge and the park would continue in the long term to enhance forage and attract elk to treated areas, as under baseline conditions and Alternative 1. Effects from successful land acquisition within refuge boundaries would also continue under the long term. Many elk that now winter on the refuge could find the Gros Ventre feedgrounds and remain in that area for the winter and possibly in other seasons.

The distribution among segments would differ from averages over the last several years. Elk numbers in the park segment would experience major decreases, down to between 500 and 1,000 elk compared to existing conditions of approximately 2,400–3,600. Elk numbers in the other three segments (the Gros Ventre, Teton Wilderness, and Yellowstone segments) would experience minor to moderate decreases if increased use of native winter range did not occur. If use of winter range did increase, as anticipated, elk numbers from these segments would experience minor decreases to minor increases.

**Elk Behavior, Social Interactions, and Nutrition**

**Short-term Effects**

Aspects of Alternative 3 that would influence elk behavior and social interactions in the short term include possible brucellosis vaccination, changes in hunting practices, and gradual reductions in the number of elk wintering on the refuge and years of supplemental feeding. Fewer elk, the reduction of supplemental feeding years, changes in hunting areas, possible changes in irrigation and cultivation on the refuge, and habitat enhancements on and off the refuge would affect elk nutrition.

As hunting and reductions in winter feeding took place, fewer elk and bison would spend the winter on refuge lands. Interactions among elk and displacement of elk by bison would likely decrease as a result, both overall and particularly in years when no supplemental feed was available. During feeding years the types of interactions that occur now would continue, although eventually at a lower level as progressively fewer animals were aware of the feedlines. Competition for standing forage following the cessation of feeding would increase over that during feeding, as it does now. Because bison numbers would be held to 800 to 1,000, displacement of elk by bison would be less of an impact than under Alternative 1.

Changes in hunting practices would also cause short-duration adverse effects, with the extent dependent on disturbance levels. Opening the southern part of the refuge early in the season would cause agitation and nervousness, increased energetic expenditures from running from hunters and the sounds of weapons firing, and a possible loss of nutrition as elk altered their foraging behavior. These elk would respond especially strongly to gunfire and human activities because they have become accustomed to the lack of hunting in these areas. They could experience prolonged periods of disturbance if they ran from the newly established hunt area to other long-established areas. Conversely, closing traditional harvest areas, such as the Blacktail Butte / Kelly hayfields area in the park and the northern portion of the refuge, would decrease elk agitation, nervousness, energetic expenditures from running, and potentially enhance nutrition by encouraging foraging.

The beneficial effects on social interactions of reducing supplemental feeding on the refuge under Alternative 3 would be similar to but less intense than effects under Alternative 2. Both competition among elk, and displacement of elk by bison would decrease with smaller numbers, and far
fewer animals than under Alternative 1 would occupy the refuge during feeding years.

Nutrition for those elk on feedlines during the estimated 2 of 10 winters that they were fed (severe winters only) would be similar to those using the feedlines now. Ration or pellet composition might need to be changed to allow for a later start of supplemental feeding. A higher fiber formula, as recommended by Baker and Hobbs (1985) for mule deer, might be one possibility. Because the method of reducing feeding would eliminate feeding first in the mildest winters with the lowest snow cover and greatest access to vegetation, nutrition gained by foraging on native winter range would remain high and would be negligibly affected in those years. As supplemental feeding was reduced to fewer winters, and elk made greater use of native vegetation during increasingly severe winters, nutritional status could be decreased. However, ongoing reductions in elk numbers would gradually offset these effects on nutrition.

Under Option A irrigation and cultivation practices, and the nutrition available to elk and bison feeding on standing forage, could be similar to baseline conditions.

Under Option B conversion of cultivated fields to native vegetation on the refuge would decrease the amount of available forage but increase nutritional content of what remained. Despite a 50% reduction in available forage on areas that had been under cultivation, conversion to native species, particularly bunch grasses that hold nutrients in plant parts longer than some cultivated species, would at least partially offset losses in mild years (Brock, pers. comm. 2003). During winters with above-average snow, if snow depths made this vegetation inaccessible to elk, nutrition and body condition would be poorer. Total herbaceous forage amounts would be similar to those described under impacts of Alternative 2, and less than under baseline conditions and in the short term under Alternative 1 by a minor amount.

As noted above, activities associated with vaccination could cause increased nervousness and excitability in elk. During acclimation activities, some animals could become frightened and leave feedlines because of these activities. Others could remain outside the feeding area and not benefit from supplemental feeding. Agitated elk could gore others, expend energy running, and be involved in social interactions more frequently than usual. If elk responded in this way, individual elk would eat less and injuries would increase. More severe effects would include escalated aggression among elk, resulting in serious injury or death, and aggressive interactions between elk and bison (B. L. Smith, pers. comm. 2002). Increased aggression could occur if elk from one part of a feedline quickly moved away and then converged on another part of the feedline already occupied by elk. Generally, these effects would be minor because they would occur in only a small portion of the population, and/or for a short period of time. However, as noted above, behavior would be monitored, and mitigation, such as maintaining a brisk pace when dispensing alfalfa pellets, would be used to minimize aggression among elk.

**Long-term Effects**

The same factors identified above would also influence social interactions and nutrition in the long term. Habitat improvement efforts outside the refuge and park could also affect nutritional status in the long term.

Fewer bison and elk would result in less intra- and interspecific competition, with fewer aggressive encounters and fewer displacements than under Alternative 1.

Vaccination activities, which would occur during feeding years if an efficacious vaccine was available, would continue to cause short-duration disturbance, including increased excitability, energetic expenditures, and aggressive interactions in the long term. Changes in hunting practices, including the closure of traditional hunting areas and the opening of new, non-traditional areas, would also cause effects similar to those described above, with the exception of increased aggressive interactions.

Because supplemental feeding would continue in severe winters (estimated to occur in roughly 2 of 10 winters depending on weather and snow conditions), standing forage on the refuge would continue to be cultivated under Option A, and numbers of elk and bison would be reduced through hunting, the nutrition of remaining elk might not be adversely affected beyond that in an unfed...
herd. Although some elk could die during above-
average winters because of decreased nutrition
and body condition, refuge elk at low numbers, as
prescribed under this alternative, might be able to
maintain good nutritional levels on native forage.

Disease Prevalence and Transmission

**Bovine Brucellosis**

*Prevalence in Herd* — Under Alternative 3 vacci-
nation of elk for brucellosis might or might not
take place, depending on whether a highly effec-
tive vaccine (>50% efficacy) was developed. Cur-
rent efficacy of Strain 19 is estimated at 25%–30%
(Thorne, Walthall, and Dawson 1981; Herriges et
al. 1989; Roffe et al. 2002) under clinical conditions
and would likely be less than 25% under field con-
ditions. Field vaccination does not prevent infec-
tion but could cause modest reductions in abortion
(Wyoming Brucellosis Coordination Team 2005).
Compared to Alternative 1, brucellosis prevalence
in the Jackson elk herd would not be expected to
change in the very short term under Alternative 3
if vaccination did not occur. Over the initial 10–15
year period in which hunting would be stepped up
and supplemental feeding phased out, brucellosis
prevalence in elk on the refuge would begin to
decline, even in the absence of vaccination.
Changes in where hunting was allowed and habi-
tat enhancement outside the park and refuge
would also encourage wider dispersion of elk and
bison. These factors would combine to reduce
prevalence in elk by a moderate amount (high end
of moderate range) in the long term compared to
Alternative 1. Prevalence in the absence of vacci-
nation would be higher than under Alternative 2,
as supplemental feeding would continue in severe
winters. The number of viable bacteria expelled
during an abortion is extremely high (Alexander,
Schnurrenberger, and Brown 1981; Davis et al.
1995) and a single abortion on a feedline could ex-
pose many of the elk feeding there at the time
(Thorne 2001). For this reason, the occurrence of
winter feeding is more important than absolute
numbers of elk in determining transmission rates,
and hence prevalence.

Use of an effective vaccine could substantially
reduce prevalence regardless of other manage-
ment actions under Alternative 3. Simulations
showed that 30%–40% of all elk calves would need
to be successfully immunized (made resistant to
infection) every year for more than 25 years to
eradicate brucellosis (Gross, Miller, and Kreeger
1998). Lower levels of immunization (e.g., 10%)
reduced, but did not eliminate, brucellosis. If a
suitable vaccine was developed that is more than
50% efficacious in preventing infection and abor-
tion, and it could be delivered to approximately
80% of susceptible elk calves on the refuge every
year, a moderate reduction of 40% in seropreva-
ience for the refuge portion of the Jackson elk
herd would result (Gross, Miller, and Kreeger
1998)). This translates to an approximate 13.5%
reduction in seroprevalence across the entire
Jackson elk herd, a minor beneficial impact. Less
frequent vaccination because of reduced feeding
would decrease benefits.

*Transmission among Elk* — If a suitable vaccine
was developed and it could be delivered to a high
proportion of susceptible cows and calves on the
refuge every year, the impact would be a major
reduction in transmission among elk for the ref-
uge portion of the Jackson elk herd due to a major
reduction in prevalence and the associated decline
in the number of abortions that would occur. If no
abortions occurred, the risk of transmission would
be almost eliminated (HaydenWing and Olson
2003). In the Jackson elk herd as a whole, a mod-
erate to major reduction in the potential for bru-
cellosis transmission among elk if the vaccination
program was implemented for refuge elk would be
possible. In the absence of a vaccine, there would
still be a moderate to major reduction in trans-
mision risk for refuge elk because of the dramatic
reduction in supplemental feeding, lower elk
numbers, and wider dispersion of wintering elk.
This would translate to a minor to moderate re-
duction for the Jackson elk herd as a whole.

*Transmission from Bison to Elk* — Reductions in
the numbers of both elk and bison, in prevalence,
and in winter feeding would mean a lowered
chance of transmission from bison to elk in the
long term. There would be less chance of direct
contact between the species, and fewer abortions
on the refuge. Without elk vaccination, the risk of
transmission from bison to refuge elk would ex-
perience a moderate decrease. Vaccination of elk
and bison would result in moderate short-term
and major long-term beneficial impacts.
Septicemic Pasteurellosis

Potential impacts on prevalence of this disease would be lowest under alternatives that reduce the number of elk on the refuge and reduce the winter feeding program. Potential impacts under Alternative 3 would be expected to be among the lowest (along with Alternatives 2 and 6) of all alternatives.

Necrotic Stomatitis and Footrot

Alternative 3 (as well as Alternatives 1, 4, and 5) would supply elk on the refuge with sufficient forage through native range habitat improvements, enhanced forage production on the refuge through irrigation, and supplemental winter feeding in the worst winters. Therefore, the occurrence of necrotic stomatitis would be negligible and would not likely differ from the current two to three mortalities per year. This would likely remain the case even if forage production was discontinued (Option B) because standing forage would continue to be adequate for low numbers of refuge elk.

Outbreaks of footrot, which are associated with feedgrounds heavily contaminated with feces and icy, compacted snow conditions, would be fewer under Alternative 3 than under Alternatives 4, 5, and 1, and more common than under Alternatives 2 and 6.

Psoroptic Scabies

The negligible beneficial effects on elk health would be the same as described under Alternative 2 but more limited due to continued supplemental feeding in some years.

Helminths and Lungworms

Lungworm transmission and prevalence in elk under Alternative 3 and associated impacts would be similar to Alternative 4, greater than under Alternatives 2 and 6, and less than under Alternatives 1 and 5.

Bovine Tuberculosis and Paratuberculosis

Bovine tuberculosis and bovine paratuberculosis are not present in the Jackson elk herd. Although analyzed here, bovine paratuberculosis has only been reported sporadically in elk and should be considered primarily a disease of bison (Roffe, pers. comm. 2005). The relative risk among the alternatives that either of these diseases would become established would be low under Alternative 3 because of the reduction of winter feeding to severe winters only. Risk would be higher than under Alternatives 2 and 6 but lower than under Alternatives 1, 4, and 5. See the discussion for elk under the impacts of Alternative 1, “Disease Prevalence and Transmission” for more details.

If bovine tuberculosis or paratuberculosis became established in the refuge portion of the herd, the potential for transmission and prevalence would be lower in alternatives where density and numbers would be reduced, such as Alternative 3. The extent of this reduction would be moderate or major in the refuge elk, and minor to moderate throughout the whole Jackson herd. Moderate to major reductions in the potential for transmission from bison to elk would also occur, and prevalence in the bison herd would be moderately lower than under Alternative 1.

Malignant Catarrhal Fever

The risk of refuge or park elk or bison contracting this disease from domestic sheep would be higher in this alternative than under Alternative 1, as animals would disperse more widely. Because agencies would support attempts to establish elk migration to winter range outside Jackson Hole in both this and Alternative 2, the risk would be highest in these two alternatives. However, the continuation of cultivation and supplemental feeding in the most severe winters would continue to encourage elk and bison to remain on the refuge, risk would be less than under Alternative 2. Because Alternatives 2 and 3 would also result in a dramatic decrease in the numbers of elk and/or bison on the refuge and less contact through feedlines, transmission between elk and from bison to elk and prevalence of this disease would likely be less. Therefore, the relative potential for impacts would be lowest under Alternatives 2, 6, and 3 because elk numbers would be reduced and/or winter feeding would be reduced or would not occur.
**Chronic Wasting Disease**

Under Alternative 3 there would be a moderate increase in risk of chronic wasting disease becoming established in the Jackson elk herd compared to Alternative 1 if migration to the Green River basin was established. As noted in other sections, the presence of an infected animal does not necessarily mean the disease will be transmitted among elk wintering on the refuge. See the discussion under Alternative 2 regarding the risk of introduction.

Potential prevalence of chronic wasting disease under Alternative 3 would likely be higher than under Alternatives 2 and 6 and lower than Alternatives 4 and 5 (see Table 4-6). The primary factors in making this conclusion are the frequency of winter feeding and the number of elk.

If chronic wasting disease became established in the Jackson elk herd, it is likely that prevalence would fall within the range seen in free-ranging and confined elk (see discussion under Alternative 1). Total impact on the herd would depend on how the disease spread in the population. Prevalence and transmission of chronic wasting disease would likely be related to the proportion of population on feed, seasonal duration of feeding, and the yearly frequency of feeding.

**Calving, Age and Sex Ratios, and Recruitment**

**Short-term Effects**

Age and sex ratios could change somewhat under Alternative 3 due to increased winter mortality, hunting, and reduced prevalence of brucellosis. The increased mortality on and off the refuge not related to hunting would mainly affect free-ranging and confined elk (see discussion under Alternative 1). Total impact on the herd would depend on how the disease spread in the population. Prevalence and transmission of chronic wasting disease would likely be related to the proportion of population on feed, seasonal duration of feeding, and the yearly frequency of feeding.

Hunting mortality would initially primarily affect adult female elk, as the Wyoming Game and Fish Department would target this portion of the population to reduce herd growth. This strategy would likely result in an initial increase in bull-to-cow ratios, primarily in the Grand Teton segment and to a lesser degree in the Yellowstone segment. To achieve adequate harvest levels on cows, it might be necessary to delay closure of the north end of the refuge to hunting and the Blacktail Butte/Kelly hayfields area in the park to elk reduction until after the elk numbers on the refuge and the park were at or near objective.

Once population objectives were met on the refuge and in the park, anticipated near the end of the first 15 years of implementation, the proportion of harvested cows would decrease, perhaps declining to the point that the ratio of bulls to cows in the population could end up being lower than what it would be under Alternative 1 (where refuge cows are also hunted more frequently than bulls). The proportion of calves in the population would increase by a negligible amount.

**Long-term Effects**

The trends beginning to occur near the end of the first 15 years of implementation (see “Short-term Effects” above) would continue in the long term, with the following exceptions. After the refuge and park population objectives had begun to be achieved, or when they were nearing achievement, harvest strategies would be modified for the refuge and the park. The park elk reduction program would be designed to increase the average bull-to-cow ratio in the Grand Teton segment to 35 bulls to 100 cows and maintain it over the long term. This ratio would be higher than the baseline Jackson elk herd ratio of 24 mature bulls to 100 cows, but it would be representative of native, non-hunted populations. Summer surveys in the park have provided the best baseline estimates for bull-to-cow ratios, which have ranged from 12 to 29 mature bulls to 100 cows (GTNP unpubl. data). This would be a minor to major increase in the proportion of bulls, as compared to baseline conditions and Alternative 1.

Increasing the bull-to-cow ratio in the park would result in only a minor increase in the ratio in the Jackson elk herd, because this segment would comprise only about 9% of the larger herd. Increases to the Jackson elk herd ratio due to a higher bull-to-cow ratio in park elk would be less than under Alternative 5, and greater than under Alternative 4. Bull-to-cow ratios in the other herd segments would not be expected to change because overall numbers in these herd units would not change appreciably.

It is currently estimated that brucellosis reduces calf production by up to 5% on the refuge (Olde-
Impacts on the Jackson Elk Herd: Impacts of the Alternatives — Alternative 3

meyer, Robbins, and Smith 1993, as adjusted for lower seroprevalence). This loss would decrease by a minor to moderate amount without vaccination under Alternative 3 simply from the likely reductions in prevalence and transmission discussed above. If vaccinations were given, the loss of calf production on the refuge would decrease by a major amount. However, vaccinating or not vaccinating would translate to a negligible benefit to calf production herdwide because the degree of calf production loss on the refuge is currently negligible in relation to the Jackson elk herd as a whole.

If septicemic pasteurellosis infected the Jackson elk herd, it would affect production and recruitment through increased mortality (see “Mortality” section below). Potential impacts on production and recruitment under Alternative 3 would be similar to those under Alternatives 2 and 6 and lower than under all other alternatives.

If bovine tuberculosis, chronic wasting disease, or other non-endemic infectious diseases were to become established in the Jackson elk herd, the rate of transmission would likely be considerably less than under Alternative 1. If losses in any particular sex or age class from these diseases occurred, hunting strategies could be changed to meet objectives. If herd size decreased because of disease, hunting could be stopped temporarily or fewer tags issued. Given expected low prevalence of any introduced infectious diseases and the ability to absorb any losses by small changes in harvest strategies, impacts to production and recruitment would likely be negligible.

Mortality

Short-term Effects

Harvest mortality during the short term would be increased compared to baseline conditions and Alternative 1. The harvest program would be primarily responsible for a 60%–85% decrease in elk numbers on the refuge, from approximately 5,000–7,500 to an estimated 1,000–2,000 by year 15 of plan implementation. Non-harvest mortality would gradually increase by a negligible amount as the refuge feeding program was concurrently scaled back and greater reliance on native vegetation occurred during all but severe winters, especially if the fence on the southern and southwest

ern sides of the refuge prevented access to some native winter range. The initiation of winter feeding would be based on established criteria (monitoring of snow conditions, pre-winter forage production, forage offtake and availability, and elk condition and movements). If necessary, supplemental feeding would be provided in some additional years to prevent high mortality. With elk at low numbers on the refuge, it is estimated that feeding would be needed in only the most severe winters to achieve this objective.

As refuge elk density decreased, fewer brucellosis-caused abortions (which currently reduce potential births by an estimated 5%) would occur, partially offsetting increases in mortality described above.

Long-term Effects

In the long term harvest on the refuge and in the park would decrease substantially from baseline conditions and compared to Alternative 1 because of fewer elk wintering on the refuge. Harvests could be more conservative in years following greater non-harvest elk mortality. In many years total harvest in the herd unit would remain similar to baseline conditions and Alternative 1.

Non-harvest mortality in the Jackson elk herd would range from 1% to something less than 16% over baseline conditions, depending on the severity of the winter. This range was based on modeled estimates (Hobbs et al. 2003) adjusted for objective herd size and the use of the Gros Ventre feedgrounds. In mild winters mortality would be lower than in winters of above-average severity. In the most severe winters supplemental feeding of refuge elk would keep mortalities close to the existing 1%–2%. Initiation of supplemental feeding would be based on assessments of forage utilization (done jointly by WGFD and NER personnel) and potentially on the January 1 index of winter severity calculations for elk (Farnes, Heydon, and Hansen 1999). Barring the spread of infectious and fatal disease, this part of the Jackson herd would not be expected to experience mortality rates higher than 5%. An estimated 2,500 elk are also fed on the Gros Ventre feedgrounds and would experience only limited mortality. Given these factors, the 16% Jackson herd mortality modeled for above-average winters is likely too high.
Non-hunting winter mortality that occurred when elk were not being supplementally fed would result both directly and indirectly from poor physical condition, energetic debt, and weight loss associated with competition for native forage. Refuge elk at low numbers would be able to maintain good nutritional levels on native forage in most winters.

Indirect impacts resulting from a loss of body condition in some elk would be increased susceptibility to predation by mountain lions and wolves.

Reduction in the prevalence of psoroptic scabies under Alternative 3 from decreases in density and numbers of elk would decrease adult bull mortality negligibly compared to Alternative 1.

Impacts from septicemic pasteurellosis on mortality under Alternative 3 would be similar to those under Alternatives 2 and 6 and lower than under all other alternatives.

Increased dispersion and lowered densities resulting from actions in this alternative would decrease the potential that bovine tuberculosis would spread in Jackson elk should elk in the herd contract the disease compared to Alternative 1. Potential impacts on mortality would be greater than under Alternatives 2 and 6 and lower than all other alternatives.

Potential prevalence of chronic wasting disease and impacts on mortality would likely be higher than under Alternatives 2 and 6 and lower than under all other alternatives (see Table 4-6 and the discussion under “Mortality” under Alternative 2 for more detail).

Health, Sustainability, and Naturalness

Short-term Effects

The health and sustainability of the Jackson elk herd would increase gradually as supplemental feeding on the refuge was progressively reduced to fewer years, elk relied more on standing forage, and animals were more widely distributed. Ungulate concentrations would be gradually reduced on the refuge over 10–15 years. As described above, the prevalence of existing diseases and the risk of transmitting these or any new diseases should they become established in the herd would also decrease with lower numbers and densities of elk on the refuge. Effects would be similar but more limited than what would occur under Alternative 2 because supplemental feeding and high ungulate concentrations would continue to occur in severe winters.

Herd health would also increase if a safe vaccine was developed with an efficacy of 50% or better and elk were vaccinated.

Barring the introduction of a serious non-endemic disease, the Jackson elk herd would be between an estimated 8,000 and 11,000 animals and would continue to be genetically viable.

Naturalness would also increase gradually in the short term under Alternative 3 as elk increasingly dispersed according to the availability of native forage. Natural phenomena, such as winter weather and predators, would have an increasingly stronger influence on mortality, similar to but more limited than what would occur under Alternative 2.

Long-term Effects

Health and sustainability under Alternative 3 would be similar but less than under Alternatives 2 and 6 because supplemental feeding would continue to occur in severe winters.

Forage improvements in the Gros Ventre River drainage and the Buffalo Valley would likely improve health and sustainability of the herd in the long term. The prevalence of existing disease and the risk of contracting or spreading a new disease would be lowered by reductions in the density and number of elk.

Reducing the number of winters when supplemental feeding occurred, which would reduce both numbers and density of elk and bison on the refuge, would substantially reduce the prevalence of brucellosis, with health benefits as described above. Vaccination could further reduce prevalence and increase health of the herd, although this improvement would be negligible if the vaccine could only be delivered during an estimated 2 winters out of 10. In the long term seroprevalence rates in elk would be expected to become more similar to those in northern Yellowstone National
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Park, although perhaps not as much as under Alternative 2.

Barring the introduction of a serious non-endemic disease or extreme decreases in population size, the elk herd would number between 8,000 and 11,000 animals and would be self-sustaining and genetically viable.

The long-term health and sustainability of the elk herd would be lower than Alternatives 2 and 6 and higher than Alternatives 1, 4, and 5.

As supplemental feeding was decreased, the herd would become more influenced by natural factors such as climate and amounts of native forage. Production and recruitment rates would be more natural and calves born outside the normal birthing season would be less likely to survive, similar to unfed herds. Winter mortality rates would be closer to those in unfed populations, as would sex ratios and age classes. Elk would distribute themselves more naturally and would expend more energy accessing winter forage. Continued hunting and monitoring to manage mortality and sex and age ratios would help refuge elk mimic natural, unfed populations.

Elk behavior would become more natural, similar to that described for Alternative 2, and competitive social interactions, including displacement by bison, would decrease.

Overall, Alternative 3 would result in a higher level of naturalness in the elk herd than would Alternatives 1, 4, and 5. Naturalness would be less than under Alternatives 2 and 6, mainly because of continued winter feeding in some years.

Conclusion

In the long term under Alternative 3 there would be an estimated 7,900–11,000 elk in the Jackson elk herd. The herd would be smaller than under baseline conditions and Alternative 1 in some years, similar in size to Alternatives 2 and 6, and smaller than under Alternatives 4 and 5.

Alternative 3 would decrease numbers of elk that winter on the refuge. Over time, most of the elk wintering on the refuge would be part of the Grand Teton segment that summers in the park. Hunting and reduced supplemental feeding would result in decreases of this segment from approximately 2,400–3,600 to 500–1,000, a major reduction compared to current conditions.

The elk herd would increase its movements and distribution due to reductions in the supplemental feeding program, and increased winter mortality would occur. In the long term the herd would be more heavily influenced by natural conditions, and winter mortality would fluctuate with winter severity, precipitation regimes, and standing forage in most years. Recruitment and annual survival would decrease compared to Alternative 1 and would be closer to levels found in non-fed populations in similar environments.

The risk of a non-endemic infectious disease quickly spreading through the elk population would be lower than under Alternatives 1, 4, and 5, and higher than under Alternatives 2 and 6 because supplemental feeding and high ungulate concentrations would continue to occur in severe winters. The prevalence of brucellosis in the Jackson elk herd would be moderately lower than under Alternative 1.

Alternative 3 would result in higher levels of long-term health, sustainability, and naturalness in the Jackson elk herd than what would occur under Alternatives 4 and 5 although levels would be somewhat lower than under Alternatives 2 and 6. Nutritional status, distribution, behavior, and sex and age ratios in refuge elk would more closely mimic those of a natural, unfed population.

Barring the introduction of serious non-endemic disease, Alternative 3 would not impair the elk population in the park. Alternative 3 would have a lower potential for impairment than would Alternatives 1, 4, and 5, and a higher potential for impairment than under Alternatives 2 and 6.

Alternative 4

Under this alternative approximately 5,000 elk and approximately 500 bison would winter on the refuge. After the initial implementation phase the agencies would adaptively manage the bison and elk populations to achieve desired conditions. Forage production on the refuge would be increased, and supplemental feeding would be reduced, based on a structured framework to progressively transition elk from intensive supple-
mental feeding to greater reliance on free-standing forage on the refuge as well as in the national park and forest. Elk hunting on the refuge and the elk herd reduction program in the park would continue when necessary, and a refuge bison hunt would be initiated. Vaccination with Strain 19 for elk and RB51 for bison would be used as long as it was logistically feasible and safe for wildlife.

Analysis

Elk Numbers Wintering on the National Elk Refuge and on Native Winter Range

Short-term Effects

The number of elk wintering on the National Elk Refuge would be gradually decreased to approximately 5,000 from 5,000–7,500 under baseline conditions and Alternative 1. This decrease would be accomplished through a short-term increase in harvest in the park and on the southern part of the refuge. The reduction in herd size would come primarily from the park segment. After elk numbers reached objective levels, the reduction of supplemental feeding would help maintain wintering elk at objective levels. Because feeding might not occur in some years, a progressively larger portion of the Jackson herd could become accustomed to wintering in native range and numbers on the refuge would decrease (B. L. Smith, pers. comm. 2003; see “Distribution and Movements of Elk” in Alternative 2 for more information).

Numbers on native winter range during supplemental feeding on the refuge would remain similar to the 2,900–5,200 under baseline conditions and Alternative 1 for the first several years, but could increase if more elk became accustomed to using native winter range.

Long-term Effects

Through a combination of hunting and forage production, the refuge would continue to be managed to support approximately 5,000 elk, a moderate reduction from Alternative 1. Some elk that were not hunted would disperse to native winter range during years when supplemental feed was not available; the number of elk wintering on native range would be less than under Alternatives 2, 3, or 6, but greater than Alternatives 1 and 5.

Although hunting would target the Grand Teton segment of the herd, similar to Alternative 3, the number of elk wintering in the park would continue to be similar to baseline levels and could increase slightly during non-feeding years. The number of elk summering in the park would decrease. Winter range enhancement efforts by the U.S. Forest Service, the Wyoming Game and Fish Department, and other partners in Bridger-Teton National Forest would help sustain higher numbers of elk in these areas in winter than what occurs under baseline conditions or under Alternative 1.

Elk Numbers in the Jackson Elk Herd

Short-term Effects

Changes in the refuge wintering population due to short-term increased harvest and reductions in supplemental feeding could result in a short-term, negligible to minor reduction in total herd numbers.

Long-term Effects

As supplemental feeding was reduced and hunting continued, the Jackson herd would continue to decrease to a level at or above the herd objective of 11,000 animals. If the lowest likely numbers were used for the number of elk on native winter range during the last 15 years (4,400), plus the approximate number of elk on the refuge (5,000) and the approximate number of elk fed on the Gros Ventre feedgrounds (2,500), the total of 11,900 would be slightly above the herd objective of 11,000 elk. This total would likely be a low estimate even for severe winters, as supplemental food would be provided on the refuge and numbers of elk on the refuge would be in excess of 5,000.

Distribution and Movements of Elk

Short-term Effects

Aspects of Alternative 4 that would influence elk movements and distribution in the short term include reduced supplemental feeding on the refuge, enhanced cultivation practices on the refuge, enclosures to protect woody vegetation, changes in hunting practices, habitat enhancements, and brucellosis vaccination.
As the number of elk wintering on the refuge was reduced to objective levels, supplemental feeding on the refuge would be gradually reduced, and elk movements and distribution would increase due to greater reliance on standing forage and native winter range. Wider distribution could become more common. Strategies such as an early season hunt in the southern third of the refuge would further increase elk movements and distribution away from this traditionally safe area and toward areas to the north and east, at least temporarily. These elk, primarily from the Grand Teton segment, could move to the northern part of the refuge, or perhaps north and east into Bridger-Teton National Forest.

The agencies would work closely with the Wyoming Game and Fish Department and landowners, including the local livestock community, to coordinate actions that would prevent conflicts due to elk dispersal and to defray costs of managing potential conflicts. Preventing access to food/hay rewards on private lands would be vital for effective management.

Farming practices would continue to attract elk to cultivated fields on the refuge, as occurs under baseline conditions and would continue to occur under Alternative 1. Enhanced irrigation and cultivation, including increased use of sprinkler irrigation, would aim to increase forage production and quality compared to current levels and would likely increase time spent by elk in cultivated fields. In years when snow crusting events made cultivated fields with high forage production inaccessible to elk, mechanical means could be used to increase access for elk.

The three exclosures designed to protect woody vegetation (1,600 acres compared to less than 20 acres under baseline conditions) would cause localized changes in ungulate distribution. Elk would lose access to approximately 7% of available acreage on the refuge, and densities would likely increase to a minor extent until the refuge wintering herd was reduced to objective levels.

The aspen exclosure, as currently designed, would be wider east to west than north to south, and could hinder north-south movements of elk. Although the fence would be designed to minimize this effect, concave areas of fence could temporarily stop elk and direct their movements (Cole, pers. comm. 2003).

A negligible amount of prescribed fire on the refuge, as well as in the park, would continue to enhance forage and habitat and attract elk to treated areas, as under baseline conditions and Alternative 1. In addition, the U.S. Forest Service, the Wyoming Game and Fish Department, and other partners would enhance habitat in Bridger-Teton National Forest east of the refuge in the Gros Ventre River basin and in Buffalo Valley, which would increase elk distribution, particularly in years when feeding did not occur on the refuge.

If attempts to acquire conservation easements or of private lands within approved refuge boundaries were successful, these procurements would prevent further loss of habitat to development, providing elk with continuing sources of good habitat and promoting wider distribution.

The Fish and Wildlife Service would permit the Wyoming Game and Fish Department to vaccinate elk using Strain 19 until a more efficacious vaccine was available. Vaccine delivery would take place during winter supplemental feeding on the refuge, causing short duration disturbance and negligible to minor changes in movements and distribution (USFWS 2002a; see the impact discussion under Alternative 3). Elk responses could vary on a daily basis from negligible effects to temporary moderate effects, such as elk leaving the vicinity of the feeding area where vaccine delivery was taking place. If a sufficiently effective oral vaccine was developed that would be safe for elk and bison, as well as non-target species, and that could be delivered on a wider scale than on feedgrounds, then vaccine delivery could temporarily change distribution because it would be delivered in feed.

**Long-term Effects**

Changes in elk movements and distribution would stem primarily from reduced supplemental feeding, converting to sprinkler irrigation, enhancing winter range in Bridger-Teton National Forest, substantially reducing the number of elk in the park, and moderately reducing elk on the refuge or opening the southern third of the refuge to limited public use. Vegetation exclosures on the refuge would continue to cause minor changes in elk
movements and distribution. Vaccination activities would continue to produce negligible to minor short-duration effects. These effects would occur only during years of supplemental feeding unless oral delivery becomes possible.

Moderate to major reductions in the number of elk from hunting would decrease densities. The objective for numbers of the park herd segment that winters on the refuge would be approximately 1,600, below baseline conditions and numbers under Alternative 1.

Vegetation exclosures would continue to cause localized changes in ungulate distribution and block access to approximately 9% of total available acreage on the refuge. The aspen exclosure in the northern part of the refuge would increase densities to a minor extent in the approximately 200 elk that traditionally winter there. Although exclosures to protect willow and cottonwood in the southern part of the refuge would decrease the number of acres available to elk by 1,100, elk densities would decrease by a minor amount because of lower elk numbers on the refuge. During periods without supplemental feeding, densities would likely decline further due to reliance on standing forage and native vegetation, and wider distribution. Feedline concentrations of approximately 500 elk per acre would continue to occur on average for about 2 hours daily during supplemental feeding periods.

The shape of the aspen exclosure would continue to temporarily stop elk and direct their movements (Cole, pers. comm. 2003).

In the long term under Alternative 4 monitoring of habitat improvement might indicate that adaptive management changes to planned exclosures were needed. Large, permanent exclosures could be made smaller, temporary, and rotated, similar to exclosures described under Alternative 6. If these changes were made, Alternative 4 impacts due to exclosures would be similar to those under Alternative 6.

Reduction of supplemental feeding would stimulate many elk that have traditionally wintered on the refuge to increase their use of surrounding native winter range. Elk would disperse to areas of suitable winter range on the refuge and in the park, as well as to adjacent federal areas where habitat would be enhanced under this and other alternatives. More elk might use areas immediately east of the refuge and the Gros Ventre River drainage; some elk could discover the Gros Ventre feedgrounds, increasing densities in these areas in winter and possibly other seasons. Others might move to nearby areas in the southern part of the park and winter on south-facing hills or other areas with forage available due to less snow cover. If elk attempted to move to potential winter range south of Jackson in the Snake River Canyon or in the lower portions of the Hoback Canyon, state feedgrounds in these areas might stop many elk from moving farther.

Most of the shift in winter distribution would involve elk in the Yellowstone, Teton Wilderness, and Gros Ventre segments. The Wyoming Game and Fish Department might be able to adjust hunting strategies to help elk find and stay on enhanced winter range (Kilpatrick, pers. comm. 2003). Elk in the Grand Teton segment would be the most likely to continue wintering on the refuge. These changes in distribution and movements would be less extensive than under Alternatives 2 and 3.

Elk numbers in the Grand Teton segment would experience moderate to major decreases from Alternative 1. Elk numbers in the other three segments would experience negligible to minor decreases if use of native winter range did not increase. If use of winter range did increase, elk numbers from these segments would experience minor increases.

**Elk Behavior, Social Interactions, and Nutrition**

*Short-term Effects*

Aspects of Alternative 4 that would influence elk behavior and social interactions in the short term include reductions in elk and bison numbers on the refuge, gradually reduced supplemental feeding on the refuge, changes in hunting practices, and brucellosis vaccination. Fewer elk and bison, reduced supplemental feeding, changes in irrigation on the refuge, and habitat enhancements on and off the refuge would affect elk nutrition.

The displacement of elk during competition with bison for forage in transitional and winter habitat on refuge, park, and adjacent lands would gradu-
ally decrease under Alternative 4 as bison and elk numbers were lowered during the initial 10–15 years. During the early years concurrent reductions in winter feeding would offset this effect to some degree on the refuge because elk and bison numbers, although decreasing, would be similar to baseline conditions and higher than the objectives. As ungulate numbers decreased and supplemental feeding was reduced, competition and aggressive social interactions on the refuge would also be reduced, although some competition for forage during non-feeding periods would occur. With less supplemental feeding, elk and bison distribution would increase as the animals relied more on native winter range. Fewer animals would be present on the refuge.

Changes in hunting practices would also cause short-duration adverse effects, with the extent dependent on disturbance levels. Harvesting elk on the southern part of the refuge early in the season would disturb elk in these traditionally safe areas, increasing agitation and nervousness, energetic expenditures, and possibly decreasing nutrition because of reductions in foraging.

Vaccination for brucellosis, using Strain 19 initially and other more efficacious vaccines when available, would cause negligible to minor short-duration adverse effects due to disturbance during supplemental feeding. If the vaccine was delivered only during supplemental feeding, disruptions would gradually become less common during the initial 10–15 years of Alternative 4. The specific types of behavioral changes associated with vaccination are described in the “Elk Behavior, Social Interactions and Nutrition” section in Alternative 3.

Nutritional status under Alternative 4 could be enhanced initially through changes in irrigation to enhance refuge forage production, along with habitat enhancements on and off the refuge. At the same time, changes in the refuge supplemental feeding program could begin to affect elk nutrition. These potential changes include alterations in the timing of feeding and providing supplemental feed in fewer years. To allow for later starts of supplemental feeding, ration or pellet composition might need to be changed. A higher fiber formula, as recommended by Baker and Hobbs (1985) for mule deer, might be one possibility. As these changes were implemented, more elk could experience lower nutrition, although the decrease would have negligible adverse effects overall on refuge elk. Toward the end of the short term increases in forage production and decreases in the number of elk on the refuge would mean better nutritional status for refuge elk.

Long-term Effects

Because the number of bison wintering on the refuge would be decreased, displacement of elk by bison during competition for standing forage would decrease under Alternative 4. If shortages of standing forage occurred during periods without supplemental feeding, aggressive social interactions involving competition for food with other elk and with bison would increase.

In the long term nutritional status could be lower in some years than under baseline conditions and Alternative 1, although the decrease would have negligible adverse effects. Supplemental feeding would continue to occur during severe and above-average winters. Exclosures would remove a negligible amount of herbaceous forage compared to baseline conditions and Alternative 1. Still, more forage would be available per elk because of reduced numbers of elk and bison.

The effects of prescribed fire, habitat enhancements, changes in irrigation and hunting practices on the refuge, and brucellosis vaccination described in the short term, would continue.

Disease Prevalence and Transmission

Bovine Brucellosis

Prevalence in Herd — Alternative 4 includes the use of existing Strain 19 brucellosis vaccine for elk until a more effective vaccine is developed. Vaccination with Strain 19 would provide some level of protection against brucellosis-induced abortion and infection in elk (Thorne et al. 1981, Roffe et al. 2002).

The Wyoming Game and Fish Department conducted several clinical trials on the use of Strain 19 Brucella abortus in vaccinating cow and calf elk (Thorne et al. 1981; Herriges et al. 1989). Combined results suggest that Strain 19 may provide protection in 30% of vaccinated cow elk when they are exposed to Brucella organisms in the
field at doses that do not exceed 7.5 \times 10^7 colony forming units (CFU). In field situations, \textit{Brucella} organisms can range in concentration from 2.4 \times 10^6 to 1.4 \times 10^{13} CFU per gram of infected fetal materials and vaginal exudates associated with live births and abortions (Alexander, Schnurrenberger, and Brown 1981; Thorne 2001). Several reports question the validity of the results of WGFD vaccination trials based primarily on flaws in scientific method (Smith and Roffe 1997; Adams, Peterson, and Williams 1998; Burnham, McCarty, and Anderson 1998; Garton 1998).

It appears that a single dose of Strain 19 may be as high as 25\% effective in calves under clinical conditions (Roffe et al. 2002; Herriges et al. 1989). For Strain 19 to be as effective in field conditions, the following assumptions must be met:

1. All biobullets would effectively administer the proper dose of Strain 19 and the trauma associated with the impact of the bullet would not hinder the transmission of Strain 19 to the elk’s body.
2. Strain 19 would be administered to calves before they became infected by \textit{Brucella} in the field.
3. Vaccinated calves that later became pregnant would be at a high nutritional status during their pregnancy.
4. Vaccinated elk would not subsequently become exposed to \textit{Brucella} organisms at significantly higher doses than used in clinical trials.
5. Immunity to a field strain dose of \textit{Brucella} would not require booster vaccination of older animals.

To the extent that these assumptions were not met under field conditions, the efficacy of Strain 19 in calves under field conditions would be less than 25\%. Field vaccination does not prevent infection but would cause modest reductions in abortion (Wyoming Brucellosis Coordination Team 2005).

When abortions occur on feedlines, other elk commonly investigate, and sniff and/or lick aborted fetuses and associated vaginal material (Thorne et al. 1978) where the concentration of \textit{Brucella} organisms is significantly higher than doses used in clinical trials. (Although Cook [1999, as cited by Roffe et al. 2002] calculated that a 10 centimeter diameter area of skin contained about 4.1 \times 10^6 organisms and suggested that this amount may be a “realistic field exposure.”)

It is also unknown how many calves could be vaccinated on the refuge. During 1989–91, approximately 45\% of calves and 4\% of cows were vaccinated on the refuge. Because it is more difficult to vaccinate a high percentage of cows and vaccination of cows is less effective in reducing abortions, female calves are usually the target of a vaccination effort. On WGFD feedgrounds vaccination success using air guns and biobullets is typically high (98\%–100\% of calves) because elk at the state feedgrounds are more habituated to humans. Although Alternative 4 would strive to vaccinate as many calf elk as possible, differences in feeding operations and the number of elk at each refuge feeding area may make it more difficult to attain a 98\%–100\% success rate. Vaccination efforts on the refuge since the winter of 2002–3 have been much more successful than the earlier 1989–91 efforts. During winter 2004–5, approximately 88\% of the calves counted during the winter classification were vaccinated, and during winter 2005–6 essentially 100\% of calves were vaccinated.

Vaccination would occur on the refuge only when supplemental feeding occurred because elk would be concentrated on feedlines and could become accustomed to human activity. A negligible to minor decrease in abortions from vaccination from Strain 19 could occur under Alternative 4.

The dose of Strain 19 in biobullets would induce few, if any, abortions when administered to pregnant cow elk. At doses used in earlier WGFD clinical vaccination trials, Strain 19 induced abortion in about 30\% of pregnant elk (Thorne et al. 1981). However, this problem appears to have been remedied by lower doses of vaccine (Thorne et al. 2002). This lower dose would be used in biobullets on the refuge. There do not appear to be any safety concerns in using Strain 19 to vaccinate calf elk.

An additive, minor to moderate decrease in prevalence would be associated with reductions in elk numbers and increased dispersion resulting from actions in Alternative 4. These actions include reductions in winter feeding, hunting both bison
and elk, and improving winter habitat outside the park and refuge.

Use of a vaccine that was at least 50% effective (similar to Alternative 3) could substantially reduce prevalence regardless of other management actions that would take place under Alternative 4, particularly if upwards of 80% of calves could be immunized (i.e., successfully vaccinated). In this case, 40% or more of calves on the refuge would be prevented from aborting. If the vaccine prevented infection, its effect on the refuge herd would translate to a 18%–20% reduction in seroprevalence in the Jackson herd, a minor beneficial impact. A more highly effective vaccine could achieve moderate reductions in the herd. Simulations by Gross, Miller, and Kreeger (1998) showed that immunizing 30%–40% of all elk calves every year for more than 25 years would be required to eradicate brucellosis.

Transmission among Elk — Transmission among elk would be lower than under Alternative 1 by a minor to moderate amount in this alternative in the long term because prevalence would be lower, there would be fewer elk, densities would decrease, winter feeding would be reduced, and elk would disperse to cultivated forage and native winter range, including improved habitat outside the refuge and the park. The use of Strain 19 might additionally lower the risk of transmission through negligible to minor decreases in abortion, as described above.

If a more efficacious vaccine (>50% efficacy, for example) was developed and delivered to a high proportion of susceptible elk on the refuge, transmission would decrease as prevalence and abortions decreased, e.g., by a moderate amount compared to Alternative 1. This would translate to a minor to possibly moderate decrease in the Jackson elk herd, depending on the effectiveness of the vaccine.

Transmission from Bison to Elk — Impacts under Alternative 4 would be similar to those under Alternative 3. Lower numbers of both bison and elk would reduce chances of direct contact between the species and fewer abortions on the refuge. Vaccinating elk with an effective vaccine would result in moderate, long-term, beneficial impacts, similar to Alternative 3.

Septicemic Pasteurellosis

Potential impacts on prevalence would be lowest under alternatives that reduce the number of elk on the refuge and reduce the winter feeding program. Alternative 4 would have mid-range potential for impacts compared to the other alternatives, lower than under Alternatives 1 and 5, and higher than under Alternatives 2, 3, and 6. For more detailed discussion, see the corresponding section for elk under Alternative 1.

Necrotic Stomatitis and Footrot

An increased incidence of necrotic stomatitis in the Jackson elk herd would occur if sufficient high-quality forage was not available and elk were forced to use poor forage such as coarse woody vegetation. This alternative would supply elk on the refuge with sufficient forage through native range habitat improvements, enhanced forage production on the refuge through irrigation, and supplemental winter feeding in the worst winters. Therefore, the risk of increased prevalence of necrotic stomatitis in the Jackson elk herd would be approximately equal to that under Alternative 1.

Outbreaks of footrot could occasionally occur during feeding years, particularly when compacted, icy snow conditions and high elk densities on feedgrounds coincide. The risk of outbreaks under Alternative 4 would be less than under Alternatives 1 and 5 and more than under Alternatives 2, 3, and 6.

Psoroptic Scabies

The negligible beneficial effects on elk health would be similar to Alternative 2 but more limited because the supplemental feeding program would not be reduced to the same degree. Potential prevalence under Alternative 4 would be lower than what would occur under Alternatives 1 and 5.

Helminths and Lungworms

Lungworm transmission and prevalence in elk under Alternative 4 and associated impacts would be similar to those under Alternative 3, greater than under Alternatives 2 and 6, and less than under Alternatives 1 and 5.
Bovine Tuberculosis and Paratuberculosis

Bovine tuberculosis and paratuberculosis are not present in the Jackson elk herd. Although analyzed here, bovine paratuberculosis has only been reported sporadically in elk and should be considered primarily a disease of bison (Roffe, pers. comm. 2005). The relative risk among the alternatives that either of these diseases would become established would be midrange under Alternative 4 because winter feeding would continue to occur at a moderately reduced level. Risk would be higher than under Alternatives 2, 3, and 6 but lower than under Alternatives 1 and 5. See the discussion for elk under impacts of Alternative 1, “Disease Prevalence and Transmission” for more detail. The following impact analyses assume that these diseases have been established in the herd.

If either disease became established in refuge elk, potential impacts would be slightly greater than under Alternatives 2, 3, and 6 in all categories, but lower than under Alternatives 1 and 5. Locally high densities of elk in western portions of the park and elsewhere in the Jackson herd unit might provide focal points of transmission (B. L. Smith, pers. comm. 2003).

Malignant Catarrhal Fever

There are no reports of malignant catarrhal fever occurring in the Jackson bison or elk herds (HaydenWing and Olson 2003). The risk of infection would be similar under Alternatives 4 and 5 because animal numbers would be reduced and habitat improvement and winter feeding would encourage elk and bison to remain on the refuge during winter. Risk would be less than under Alternatives 1, 2, 3, and 6.

Large changes in density would be needed to see a difference in potential impacts among alternatives. Because specific changes in prevalence in the herds, herd production, recruitment, mortality, and transmission are unknown for any of the alternatives, alternatives were ranked based on the relative impacts that could occur, should malignant catarrhal fever become established in the Jackson elk or bison herds.

The potential for impacts would be intermediate under Alternative 4 due to a moderate number of elk (approximately 5,000) and reduced winter feeding. This potential would be less than under Alternatives 1 and 5, and more than under Alternatives 2, 3, and 6.

Chronic Wasting Disease

Under Alternative 4 the risk of chronic wasting disease becoming established in the Jackson elk herd would be similar to the risk under Alternative 1 due to similar numbers of elk and frequent winter feeding. This risk would also be similar to that under Alternative 5. It would be higher than under Alternatives 2, 3, and 6 because of lower elk numbers under these alternatives and fewer elk wandering outside the herd unit area. If larger movements occurred, the risk of introduction could increase.

Prevalence of chronic wasting disease under Alternative 4 would be higher than under Alternatives 2, 3, and 6 and might be lower than under Alternatives 1 and 5 due to reduced supplemental feeding (see Table 4-6). Risk of transmission would follow this same ranking.

If chronic wasting disease became established in the Jackson elk herd, it is likely that prevalence would fall within the range seen in free-ranging elk, about 4% on average (2.3% to 9.6% range in Wyoming elk; WGFD, unpubl. data 2005), and ranging up to 59% or higher in confined elk (Peters et al. 2000; Miller, Wild, and Williams 1998). Prevalence in the Jackson elk herd might be higher than it would be otherwise, and closer to that experienced in confined situations, because elk are very concentrated in the winter when on feedlines.

Calving, Age and Sex Ratios, and Recruitment

Short-term Effects

Although age and sex ratios would initially be similar to baseline conditions and to those expected under Alternative 1, ratios would likely change somewhat under Alternative 4 due to increased winter mortality, reduced prevalence of brucellosis, and hunting. Furthermore, a larger number of elk would winter on native range, as compared to baseline conditions and Alternative 1, which would subject a proportionately large portion of the Jackson elk herd to a higher mortality rate. As in other alternatives, increased mor-
Impacts on the Jackson Elk Herd: Impacts of the Alternatives — Alternative 4

Mortality

Long-term Effects

The current bull-to-cow ratio in the park segment would be lower than in more natural (e.g., unfed, unhunted) populations and has recently varied between 12 and 29 bulls per 100 cows. Hunting would particularly harvest cow elk to help readjust this ratio and would in the long term decrease bull tags for refuge elk as needed when objectives for the number of refuge elk (approximately 5,000 under this alternative) were achieved. The agencies would work cooperatively with the Wyoming Game and Fish Department to establish and achieve objective sex ratios. The initial park recommendation would be to manage the park elk segment at 35 bulls to 100 cows on average.

The ratio of bulls to cows in the Jackson elk herd currently averages 24 to 100. Increasing the bull-to-cow ratio in the park segment, which would comprise about 14%–15% of the herd, would translated to a minor increase in the whole herd ratio. These increases would be less than under Alternative 5, in which up to 2,500 elk would be maintained in the park segment, and greater than under Alternative 3, in which the park segment would be reduced to 500–1,000 elk.

The influence of weather, less supplemental feeding, and reduced hunting of cows would all contribute to higher mortality, particularly in calves. This would be somewhat mitigated by several factors, including lower losses from existing or potential disease. However, even with vaccination of 100% of refuge calves and cows by year 3 with Strain 19, reductions in calf mortality related to lower prevalence of brucellosis and potential spread of disease not yet in the herd would be negligible.

In the long term, as the prevalence of brucellosis declined due to reduced feeding, lower elk and bison densities, Strain 19, and possibly a more effective vaccine in the future, production and recruitment would increase by a negligible amount. If a more effective vaccine was found, production and recruitment losses from brucellosis would be reduced by a moderate amount because prevalence and the number of abortions would be reduced. However, because so few calf deaths are related to brucellosis, even eliminating it from the herd would increase recruitment by less than 0.5% in any given year, which would be negligible.

If chronic wasting disease or bovine tuberculosis became established in Jackson Hole, productivity would be affected, and if mortality was additive, recruitment could be affected, mainly by lowering the number of animals that produce calves. Bovine tuberculosis could also affect age ratios because it would increase mortality in older animals particularly. See the “Mortality” section below for potential effects.

Mortality

Short-term Effects

The gradual reduction of supplemental feeding would negligibly increase mortality levels on the refuge by 3%–4% in some years compared to baseline conditions and under Alternative 1. Average winter mortality on the refuge would increase from 1%–2% annually to an estimated 1%–5%. Modeled estimates support the assessment that annual natural survival of adult elk in the entire herd has also been high, 96.8% for bulls and 97.2% for cows (Lubow and Smith 2004). After several years, a larger proportion of elk would winter on native range and be subject to natural factors affecting mortality, including loss of body condition, predation, and starvation. Supplemental feeding would be initiated according to established criteria, including pre-winter forage production, assessments of forage utilization (done jointly by WGFD and NER personnel), elk condition and movements, and potentially on the January 1 index of winter severity calculations for elk (Farner, Heydon, and Hansen 1999). Supplemental feeding could be delayed or could occur earlier compared to current practices. Overall, a higher total winter mortality rate of approximately 5% could be expected. Increases in mortality would be less than under Alternative 2 but approximately the same as under Alternative 3.
**Long-term Effects**

The same negligible increase in mortality in refuge elk related to reduced supplemental feeding and increased vulnerability to natural conditions, such as weather and predation as described above, would continue in the long term. The increase would be kept small by reducing numbers through hunting and by increasing the amount and quality of cultivated forage on the refuge.

The increase in predation and scabies would be negligible under Alternative 4, as would the loss of body condition as supplemental feed would be available during winters of above-average or severe intensity. Brucellosis would decrease in prevalence as noted above.

Under Alternative 4 mortality from septicemic pasteurellosis or from occasional outbreaks of footrot would be greater than under Alternatives 2, 3, and 6 and less than under Alternatives 1 and 5.

Because bovine tuberculosis is a chronic, slowly developing diseases, older animals tend to have higher probability of being infected (Rodwell, Whyte, and Boyce 2001) and exhibiting clinical symptoms. Adult elk mortality would increase in the long term as the number of clinical cases increased. It is likely that the absolute impact of bovine tuberculosis on productivity in the herd would be low. For example, if prevalence was 5% (as was prevalence for a Canadian elk herd; Hadwen 1942), then a maximum of 5% of the Jackson elk herd could be lost; this would constitute a negligible to minor increase in mortality.

If chronic wasting disease infected the Jackson elk herd, mortality would follow prevalence and would likely fall within the range seen in free-ranging elk (about 4% on average) and confined elk (up to 59% or higher), with effects ranging from negligible to major. Rankings of the alternatives for potential impacts from chronic wasting disease were based on winter feeding frequency and duration, as well as on the number of elk wintering on the refuge. The relative impacts on mortality under Alternative 4 would be greater than under Alternatives 2, 3, and 6 and less than under Alternatives 1 and 5 (see Table 4-6).

**Health, Sustainability, and Naturalness**

**Short-term Effects**

As in Alternatives 2 and 3 but to a more limited extent, the health and sustainability of the Jackson elk herd would be increased gradually as supplemental feeding was reduced and there was greater reliance on standing forage and wider ungulate distribution. Although high concentrations would likely continue on the refuge feedgrounds during winters when supplemental feeding occurred, brucellosis prevalence and transmission would be reduced compared to baseline conditions and Alternative 1 due to reductions in numbers, feeding, and vaccination. Alternative 4 would lower the risk of future population declines or de-population events from bovine tuberculosis, for example, or other non-endemic disease compared to alternatives with annual feeding (Alternatives 1 and 5) but a high risk could continue to be maintained by the level of supplemental feeding under Alternative 4.

Increased harvest would lower the Grand Teton segment of the refuge wintering herd, decreasing refuge elk numbers. This would produce a more sustainable situation, with fewer elk being more able to survive on standing forage without supplemental feed.

Naturalness would also increase gradually in the short term under Alternative 4 as elk increasingly dispersed according to the distribution of available forage on native range and natural phenomena, such as winter weather and predators, which would have an increasingly stronger influence on mortality in some years. Mortality could increase in average winters to an estimated 5%, compared to the 1%-2% under baseline conditions and Alternative 1. These effects would be similar but more limited than what would occur under Alternatives 2, 3, and 6.
Alternative 4 would continue to enhance health and sustainability of the Jackson elk herd in the long term, although to a lesser extent than would Alternatives 2, 3, and 6. Health and sustainability under Alternative 4 would be greater than under Alternatives 1 and 5. The reasons are similar to those described above for short-term effects.

Wider distribution of elk would result in moderate reductions in both the prevalence and potential transmission of brucellosis, as well as potential for spread of diseases not yet in the population. The transmission risk and the likelihood of major adverse impacts from other diseases would be less than under Alternatives 1 and 5, but higher than under Alternatives 2, 3, and 6.

Barring the introduction of serious non-endemic disease or extreme decreases in population size, the Jackson elk herd would continue to be self-sustaining at 11,000 animals and would maintain genetic viability. Winter mortality could increase negligibly during some winters.

Overall, the long-term health and sustainability of the elk herd would be lower than under Alternatives 2, 3, and 6 and higher than under Alternatives 1 and 5.

The elk herd would be more natural than under baseline conditions and Alternative 1 because supplemental feeding would be reduced. Natural factors such as climate and amounts of native forage would have a much greater influence on numbers, movements, distribution, and mortality. Increased use of exclosures on the refuge would alter elk distribution and reduce the naturalness of movements to some extent.

Increases in naturalness would likely be negligible under Alternative 4. Elk would distribute themselves more naturally, expend more energy accessing winter forage, and maintain a more natural, lower nutritional status, but only in mild or average winters. Production and recruitment rates would be more natural and calves born outside the normal birthing season would be less likely to survive in these years. Winter mortality patterns would be more natural compared to the baseline level and Alternative 1 due to a reduced winter supplemental feeding program and greater elk use of native winter range and standing forage.

Elk behavior would also become more natural. Competitive social interactions associated with feedlines would decrease.

Elk reduction for the park segment could help achieve a more natural bull-to-cow ratio for both refuge elk and in the Jackson herd.

Possible increases in elk distribution during some non-feeding years might cause more animals to be killed by vehicles or agency removals, but these increases in mortality would likely be negligible.

Alternative 4 would result in a higher level of naturalness in the elk herd than would Alternatives 1 and 5. Naturalness would be less than under Alternatives 2, 3, and 6 mainly because of the continuation of winter feeding, although it would be moderately reduced.

Conclusion

In the long term under Alternative 4 there would be an estimated 11,000 elk in the Jackson elk herd and fewer elk wintering on the refuge. The herd would be similar in size to that under Alternatives 1 and 5, and larger in some years than Alternatives 2, 3, and 6.

Compared to Alternative 1, Alternative 4 would emphasize enhanced forage production on the refuge to sustain approximately 5,000 elk. Reducing supplemental feeding, in addition to creating a disturbance on the southern end of the refuge, would decrease elk numbers and densities. Approximately 1,600 acres of exclosures on the refuge to protect woody vegetation would alter distribution and increase elk densities outside the fences. Together, these influences could cause densities on the refuge outside the feedlines to remain the same as under Alternative 1. Non-harvest mortality would increase negligibly from baseline conditions.

More elk in the Jackson herd would increase their movements and distribution and respond in a more natural way to winter forage availability, compared to baseline conditions and Alternative 1, due to greater reliance on native range and standing forage. Negligibly increased winter mortality could occur in some years.
The risk of a non-endemic infectious disease quickly spreading through the elk population would be intermediate among the alternatives. The risk would be lower due to reduction of winter feeding and fewer bison and elk, but higher than under Alternatives 2, 3, and 6. Alternative 4 would have an intermediate risk of such a disease having major adverse impacts to survival and population sustainability.

The prevalence of brucellosis in the Jackson elk herd would be moderately lower than under Alternative 1. Strain 19 would be used to vaccinate elk on the refuge during supplemental feeding periods and would be replaced when a more efficacious vaccine was available for use. Lower levels of infection in the herd would negligibly increase elk numbers due to reduced abortion rates. The approximately one-third of the Jackson elk herd that spends the winter on native range would not be directly affected by Alternative 4, although competition for native forage could increase when supplemental feeding was not provided on the refuge.

Alternative 4 would result in higher levels of long-term health, sustainability, and naturalness in the Jackson elk herd than what would occur under Alternatives 1 and 5, and lower levels than what would occur under Alternatives 2, 3, and 6.

Barring the introduction of serious non-endemic disease, Alternative 4 would not impair the elk population in the park. If such a disease did become established in the herd, Alternative 4 would have a lower potential for impairment than would Alternatives 1 and 5, and a higher potential for impairment than Alternatives 2, 3, and 6. Although the potential risk of impairment would be lower than under Alternative 1, potential risk would be elevated somewhat due to continued feeding of elk and bison on the refuge.

After the initial implementation phase and herd and habitat objectives were achieved, adaptive management actions might be incorporated that could further reduce supplemental feeding and alter ungulate numbers on the refuge. To the extent that these actions were possible, impacts due to the exclosure design and potential impacts from disease would be more similar to impacts described for Alternative 6.

**ALTERNATIVE 5**

This alternative would be similar to Alternative 1, as supplemental feeding would continue as it is now. Changes include improved irrigation to help increase forage production on the refuge, fencing of woody vegetation, a bison hunt on the refuge to reduce numbers to 350–400, and vaccination of elk with Strain 19. Although elk hunting would continue, the park segment would be targeted.

**Analysis**

**Elk Numbers Wintering on the National Elk Refuge and on Native Winter Range**

Approximately 5,000–7,500 elk would winter on the refuge. Refuge elk numbers would remain similar to baseline conditions and numbers under Alternative 1. If the Jackson elk herd objective was met and maintained, the average number of elk on the refuge would be approximately 5,574. This number is the average of elk counted during five of the last six winters (a partial count was not included), adjusted for a Jackson elk herd size of 11,000.

Adjusted estimates of elk numbers on native winter range would range from 2,900–5,200, and average 3,700 elk, similar to baseline conditions and Alternative 1. Elk wintering in the park (360 on average) are included in these estimates.

**Elk Numbers in the Jackson Elk Herd**

Based on recent conditions (when the Jackson elk herd ranged from 13,000 to 15,000), herd totals would likely be higher than the herd objective (11,000) on average if elk wintering on the refuge numbered between 5,000 and 7,500. Achieving the 11,000 herd size objective would be difficult without reducing the number of elk on the Gros Ventre feedgrounds or on native winter range. For example, elk on native winter range now number about 4,400–7,900, the Gros Ventre feedgrounds averages 2,500 elk, and the number at the refuge and in the park ranges from 5,000 to 7,500 elk. At the low end of the range, this totals 11,900, and at the high end, 17,900. If the refuge elk number remained the same, their either mortality would need to increase for elk wintering on native forage or feeding on the Gros Ventre feedgrounds would need to be reduced, to achieve whole herd objectives.
Impacts on the Jackson Elk Herd: Impacts of the Alternatives — Alternative 5

Distribution and Movements of Elk

The changes in this alternative that would affect distribution and movements of elk include the fencing of woody vegetation, doubling cultivated forage on the refuge, and hunting geared to reduce elk numbers in the Grand Teton segment. Alternative 5 would have negligible to minor effects on elk movements and distribution compared to baseline conditions and what would occur under Alternative 1.

Alternative 5 would increase sprinkler irrigation to enhance forage production and quality compared to current levels, resulting in elk spending more time in cultivated fields. In years when snow crust ing events made cultivated fields with high forage production inaccessible to elk, mechanical means would be used to increase access for and to extend elk use of these areas. Hunting in designated areas of the park and the refuge would continue to cause elk to move through and away from these areas during harvest periods, as it does under existing management and would do under Alternative 1.

Exclosures designed to protect woody vegetation (1,600 total acres compared to less than 20 acres under baseline conditions) would cause negligible localized changes in ungulate distribution, as elk would lose access to approximately 7% of formerly available areas on the refuge. The aspen exclosure could slightly change migratory pathways of elk (Cole, pers. comm. 2003).

Harvest efforts would aim to reduce the portion of the Grand Teton segment that winters on the refuge to less than 2,500 elk, a negligible to minor impact. Elk numbers in the other three segments, the Gros Ventre, Teton Wilderness, and Yellowstone segments, would increase to a minor extent.

Vaccine delivery with Strain 19 would take place during winter supplemental feeding on the refuge, causing short-duration disturbance and negligible to minor changes in movements and distribution (USFWS 2002a; see impacts of Alternative 4).

Elk Behavior, Social Interactions, and Nutrition

Short-term Effects

Aspects of Alternative 5 that would affect elk behavior, social interactions, and/or nutrition include brucellosis vaccination, vegetation exclosures, changes in irrigation practices on the refuge, and reduced competition with bison.

Vaccination for brucellosis would take place during winter supplemental feeding on the refuge, which would occur for about 70 days during 9 of every 10 years. Vaccine delivery would cause negligible to minor short-duration adverse effects to elk behavior, social interactions, and nutrition (see descriptions in Alternatives 3 and 4).

The displacement of elk during competition with bison for forage in transitional and winter habitat would decrease under Alternative 5 during the initial 10 to 15 years of plan implementation as bison numbers were gradually reduced from about 1,000 to the objective of 350–400.

Nutrition could gradually be enhanced because the amount of native forage available to elk could increase as bison numbers were reduced. In the short term amounts of herbaceous vegetation available on the refuge would be negligibly lower than under baseline conditions and Alternative 1. Amounts would remain similar because improvements in forage production on the refuge would mitigate the loss of herbaceous forage made inaccessible by vegetation exclosures (1,600 acres).

Long-term Effects

Social interactions involving forage competition and the displacement of elk by bison would continue to be lower than under baseline conditions and Alternative 1 due to fewer bison.

Vaccination would continue to cause short-duration, negligible to minor effects due to disturbance. If oral vaccine delivery became possible, disturbance would be less than if ballistic delivery was used.

Elk nutrition could continue to be enhanced in the long term due to fewer bison, reduced competition with bison, and greater forage production on the refuge. Changes in irrigation practices would continue to mitigate the loss of forage due to exclo-
sures. Amounts of herbaceous vegetation available on the refuge would continue to be similar to, but negligibly lower than, baseline conditions and long-term conditions under Alternative 1. Greater amounts of standing forage would be available to elk primarily because bison numbers would be reduced by more than half.

**Disease Prevalence and Transmission**

**Bovine Brucellosis**

*Prevalence in Herd* — Under Alternative 5 the prevalence of brucellosis in the Jackson elk herd and transmission of brucellosis among elk would likely remain unchanged from current levels in the short term because elk numbers wintering on the refuge and the winter feeding program would be similar to the current conditions.

An attempt would be made to vaccinate 80% of calves each year. As noted in the impacts for Alternative 4, vaccination with Strain 19 could provide some modest level of protection against brucellosis-induced abortion in elk (Thorne et al. 1981; Roffe et al. 2002), although it would not prevent brucellosis infection (Wyoming Brucellosis Coordination Team 2005).

Because elk would still be fed 9 out of 10 years, and because only one abortion on the feedlines could result in many elk being infected, prevalence on the refuge would be higher than it would be in the absence of feeding. Without vaccination, seroprevalence on the refuge has declined in recent years due to natural cycling of brucellosis or through reduction of crowding on feedlines resulting from feeding program improvements (see Figure 3-3; B. L. Smith, pers. comm. 2003).

In the remainder of the Jackson elk herd, elk wintering on the Gros Ventre feedgrounds would be vaccinated by WGF personnel, while those on native ranges (approximately 32% under Alternative 5) would not. However, brucellosis prevalence in elk that winter on native range would be lower than in elk that winter on feedgrounds and would not likely change under Alternative 5.

*Transmission among Elk* — In the short term, transmission among elk would not change. In the long term a minor decrease in transmission among elk would occur because the vaccination program would serve to reduce the number of abortions that occur. The relationship between transmission risk among elk on feedlines and prevalence is not likely a linear relationship (but curvilinear) because a single abortion (which could occur even when prevalence is low) could infect the bulk of elk feeding in the area of the abortion (Thorne 2001).

*Transmission from Bison to Elk* — In the short term there would be no change in the transmission to elk with or without vaccination. In the long term, and without vaccination, a negligible decrease in brucellosis transmission from bison to elk could occur due to decreased numbers of bison, thus reducing contact between the species. This assumption may be incorrect since seropositive rates have declined on the refuge while the number of bison and transmission opportunities have increased. With vaccination, abortion and possibly potential transmission would be further reduced. Therefore, the impact could be a negligible to minor reduction in brucellosis transmission from bison to elk, compared to Alternative 1.

**Septicemic Pasteurellosis**

Potential impacts under Alternative 5 would be the same as Alternative 1, and higher than under Alternatives 2, 3, 4, and 6. For more detailed discussion, see the corresponding section for elk under “Disease Prevalence and Transmission” in Alternative 1.

**Necrotic Stomatitis and Footrot**

Because Alternative 5 would supply elk on the refuge with sufficient forage through enhanced forage production on the refuge through irrigation, and supplemental winter feeding in the worst winters, no increase in the prevalence of necrotic stomatitis over current conditions or Alternative 1 is expected.

The potential for outbreaks of footrot would be similar to that under Alternative 1 due to a similar feeding program, and lower than under Alternatives 2, 3, 4, and 6.

**Psoroptic Scabies**

There would be no impact on the prevalence of psoroptic scabies in the elk herd under Alterna-
Impacts on the Jackson Elk Herd: Impacts of the Alternatives — Alternative 5

tive 5, and there would be no impact on mortality or transmission among elk compared to baseline conditions and what would occur under Alternative 1.

Helminths and Lungworms

Lungworm transmission and prevalence in elk under Alternative 5 and associated impacts would be similar to Alternative 1 and greater than under Alternatives 2, 3, 4, and 6.

Bovine Tuberculosis and Paratuberculosis

Bovine tuberculosis and paratuberculosis are not present in the Jackson elk herd. Although analyzed here, bovine paratuberculosis has only been reported sporadically in elk and should be considered primarily a disease of bison (Roffe, pers. comm. 2005). The risk among alternatives that either of these diseases would become established would be lower than under Alternative 1 and higher than under Alternatives 2, 3, 4, and 6. See the discussion for elk under impacts of Alternative 1, “Disease Prevalence and Transmission,” for more detail. The following impact analysis assume that these diseases would become established in the herd.

Impacts on the Jackson elk herd, and all other species, associated with bovine tuberculosis under Alternative 5 would be similar to those under Alternative 1 in all categories, because elk numbers and the winter feeding program would be similar under both alternatives.

The potential for transmission of bovine tuberculosis or bovine paratuberculosis from bison to elk in the long term under Alternative 5 would be lower by a minor amount because (1) bison numbers would be reduced, and (2) prevalence in the bison herd would be lower by a negligible to minor amount. Locally high densities of elk in western portions of the park and elsewhere in the Jackson herd unit might provide focal points of transmission (B. L. Smith, pers. comm. 2003)

Malignant Catarrhal Fever

There are no reports of malignant catarrhal fever occurring in the Jackson bison and elk herds. The risk of introduction into the herds is described in greater detail under “Disease Prevalence and Transmission” in Alternative 1.

The risk of infection in Jackson elk under Alternative 5 would be lower than under Alternatives 1, 2, 3, and 6, and similar to Alternative 4. Under Alternative 5, as well as Alternative 4, numbers would be reduced and habitat improvement and winter feeding would encourage elk and bison to remain on the refuge during winter.

Potential impacts would be worst under Alternatives 1 and 5 because elk numbers and density would be highest and winter feeding would occur nearly every year. This potential for impacts would be greater than under Alternatives 2, 3, 4, and 6.

Chronic Wasting Disease

Under Alternative 5 the risk of chronic wasting disease becoming established in the Jackson elk herd would be similar to the risk under Alternative 1 and would be higher than under Alternatives 2, 3, 4, and 6.

If chronic wasting disease became established in the Jackson elk herd, prevalence would likely fall within the range seen in free-ranging and confined elk. Elk concentrations under Alternative 5 would be similar to those under Alternative 1, and higher than under Alternatives 2, 3, 4, and 6. See Table 4-6 for relative prevalence.

Calving, Age and Sex Ratios, and Recruitment

Alternative 5 would have negligible effects on calving and recruitment compared to baseline conditions and Alternative 1. Brucellosis vaccination on the refuge, alterations to hunting practices, and potential impacts from diseases could alter age and sex ratios.

Production and recruitment losses for the refuge portion of the Jackson elk herd from brucellosis would be expected to be reduced by a minor to moderate amount because prevalence would be reduced similarly, resulting in fewer abortions. It is estimated that currently there is a maximum 5% loss of elk calves to brucellosis-caused abortion on the refuge (Oldemeyer, Robbins, and Smith 1993, as adjusted for lower seroprevalence). A minor to moderate reduction in the 5% loss would
constitute a negligible increase in elk production and recruitment in the Jackson elk herd in the long term.

The risk of an outbreak of septicemic pasteurellosis, which disproportionately affects calves, would remain similar to the risk under baseline conditions and what would occur under Alternative 1.

If bovine tuberculosis or chronic wasting disease became established on the refuge, they would affect productivity, and if mortality was additive, recruitment. Numbers of calves produced each year could decline with a declining population size and fewer adult females to produce calves. These diseases could also affect age ratios because they would increase mortality in older animals particularly.

As described in Alternatives 3 and 4, harvest strategies would be modified to achieve a bull-to-cow ratio for elk in the Grand Teton segment that would mimic that in an unfed, unhunted, and more natural population. The current ratio of 12–29 bulls per 100 cows would be increased to 35, a minor to major increase in this segment, and a minor increase in the herd (see Alternatives 3 and 4 for additional information).

**Mortality**

The mortality of elk wintering on the refuge would remain low, at 1%–2%, as it is currently. Hunting would continue to take elk from the refuge, and in particular those in the park segment. Exclosures on the refuge, particularly the large aspen exclosure to the west of Long Hollow, could enhance hunter success and increase mortality by channeling elk movements during fall migration onto the refuge around fenced areas.

Potential impacts from septicemic pasteurellosis under Alternative 5 would be the same as under Alternative 1, and higher than under Alternatives 2, 3, 4, and 6.

If bovine tuberculosis infected the herd, impacts on the Jackson elk herd under Alternative 5 would be similar to those under Alternative 1. Older animals tend to have a higher probability of being infected with this chronic, slowly developing disease (Rodwell, Whyte, and Boyce 2001) and exhibiting clinical symptoms. Hence, adult elk mortality would increase in the long term as the number of clinical cases increased.

If chronic wasting disease infected the Jackson elk herd, prevalence would likely fall within the range seen in free-ranging elk (4% on average) and confined elk (up to 59% or higher). Mortality would reflect prevalence and, depending on the extent of infection, negligible to major increases could be possible. Potential impacts from chronic wasting disease under Alternative 5 would be similar to impacts under Alternative 1.

**Health, Sustainability, and Naturalness**

The health and sustainability of the Jackson elk herd would be similar to levels under baseline conditions and Alternative 1 due to continuation of nearly annual winter feeding. Alternative 5 would concentrate thousands of elk and hundreds of bison on feedlines for several months nearly every year. These annual concentrations would continue to maintain a high risk of transmission among elk if a non-endemic infectious disease became established in the herd, thereby jeopardizing herd health and sustainability in the long term. Brucellosis vaccination could decrease prevalence and increase herd health by a minor to moderate degree in the long term.

Barring the introduction of serious non-endemic disease, the Jackson elk herd would continue to be genetically viable and self-sustainable at 11,000. Alternative 5 would have no effect on elk genetic viability compared to baseline conditions and Alternative 1.

Naturalness would remain similar to baseline conditions and Alternative 1, and several population processes would continue to operate at unnatural levels. Notably, winter mortality would be lower than natural due to the winter feeding program on the refuge. Under natural conditions mortality rates are different among age and sex classes, but winter feeding tends to nullify these differences. Elk would continue to expend less energy accessing winter forage than they would without supplemental feeding, and they would continue to maintain a higher level of nutrition. Also because of the winter feeding program, recruitment rates would be unnatural, and calves born out of the normal calving season would con-
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continue to have a high chance of survival. Several of these factors could reduce fitness of the elk herd, which could have long-term implications.

Seasonal distribution and movements would continue to be unnatural under Alternative 5. Rather than many groups of elk roaming in search of available forage, as would occur naturally, the herd would continue to be concentrated together in a relatively small area for several months each winter.

Maintaining a ratio of approximately 35 bulls to 100 cows in the Grand Teton segment of the Jackson elk herd would enhance naturalness in the herd. This ratio would be representative of a native, non-hunted population and higher than under baseline conditions.

Overall, naturalness under Alternative 5 would remain similar to Alternative 1 and would be lower than under Alternatives 2, 3, 4, and 6, mainly because of the continuation of winter feeding.

Conclusion

In the long term under Alternative 5 there would be at least 11,000 elk in the Jackson elk herd. The herd would be similar in size to that under Alternatives 1 and 4, and larger in some years than under Alternatives 2, 3, and 6. The number of elk wintering on the refuge would also be similar to baseline conditions and Alternative 1.

Alternative 5 would be similar to Alternative 1, except that a vaccination program would be in place, and brucellosis-related abortions in elk that winter on the refuge could be lower by a minor degree. Elk numbers would increase negligibly due to reduced abortion rates.

Movements and distribution would be similar to baseline conditions and levels under Alternative 1 in the long term due to nearly annual winter supplemental feeding on the refuge. Large concentrations of elk would continue to focus in winter on feedgrounds and nearby areas. Production, recruitment, and annual winter mortality would remain similar to baseline conditions and Alternative 1 and would be lower than levels found in non-fed populations in similar environments.

The risk of a non-endemic infectious disease quickly spreading through the elk population would be high due to the near-annual winter feeding program. Therefore, this alternative would have a high risk of a major adverse impact to survival, population size, and sustainability. The risk would be higher than under Alternatives 2, 3, 4, and 6, and lower than under Alternative 1.

Levels of long-term health, sustainability, and naturalness in the elk herd under Alternative 5 would be higher than under Alternative 1, and lower than levels under Alternatives 2, 3, 4, and 6.

Barring the introduction of a serious non-endemic disease, Alternative 5 would not impair the elk population in the park. Alternative 5 would have higher potential for impairment from disease than would Alternatives 2, 3, 4, and 6 and would be similar potential to Alternative 1.

ALTERNATIVE 6

Alternative 6 is very similar to Alternative 2, which would minimize management and eliminate winter supplemental feeding on the refuge over time. However, under this alternative feeding would be eliminated sooner, and both elk and bison would be hunted. If an effective vaccine for brucellosis became available, it would be administered if delivery would not depend on winter feeding.

Analysis

Numbers of Elk Wintering on the National Elk Refuge and Native Winter Range

Short-term Effects

During the initial 5 to 10 years under Alternative 6, the number of elk wintering on the refuge would be reduced to an estimated 2,400–2,700. These reductions would occur primarily through hunting, particularly elk that summer in the park. This level would also be achieved through non-harvest mortality as cultivated forage and supplemental feeding were phased out, particularly in harsh winters. The number of elk on the refuge could be reduced below 2,400 if satisfactory willow recovery did not occur and additional fencing was required.
Elk on native winter range would continue to vary annually according to the severity of the winter and the stage of the feeding program reduction. Their numbers would likely initially increase during non-feeding years above the estimated 4,400–7,900 that have used native range during the last 15 years.

**Long-term Effects**

When monitoring indicated that woody vegetation had recovered to objective levels, the number of elk wintering on the refuge would be allowed to increase to an estimated 2,800–3,200, although refuge elk numbers could decrease to an estimated 1,200 in some years.

Estimated numbers of elk on native winter range would likely remain higher than estimated numbers at baseline conditions. Baseline estimates, which assume feeding during 9 or 10 winters and a total herd size of 11,000, indicate approximately 2,900–5,200 elk on native winter range (average, 3,700). Increased elk distribution due to the elimination of feeding on the refuge and habitat improvements outside the park and refuge could also help increase the number of elk subsisting on native range.

Similar to Alternative 2, numbers of elk wintering in the park could increase negligibly as reductions in the supplemental feeding program on the refuge were made. If the elk herd reduction program was eliminated in the southern part of the park, more elk might use these areas as transitional or winter range.

**Elk Numbers in the Jackson Elk Herd**

**Short-term Effects**

As reductions in the refuge feeding program progressed, winter mortality would increase and Jackson elk herd numbers would decrease.

**Long-term Effects**

In the long term the number of elk in the Jackson herd under Alternative 6 would be lower than under baseline conditions and Alternative 1. Factors decreasing elk numbers on the refuge in the long term could also lower numbers in the Jackson herd. In addition to the elimination of refuge supplemental feeding, these factors include greater elk reliance on native vegetation and forage competition with bison. Increased forage as a result of the Jackson Interagency Habitat Initiative, a joint effort of the U.S. Forest Service, Wyoming Game and Fish Department, and other partners, would help reduce winter mortality.

Total herd numbers would range from an estimated 9,300 to 11,000. This range was calculated by combining the known minimum averages of 4,400 elk on native winter range, 2,500 elk on the Gros Ventre feedgrounds, and 2,400 elk on the refuge. Total herd numbers would range from 9,700 to 11,000 if a minimum of 2,800 elk wintered on the refuge in the long term.

**Distribution and Movements of Elk**

**Short-term Effects**

Winter distribution would likely remain similar to baseline conditions for several years as supplemental feeding was phased out. Seasonal movements between summering areas and the refuge would continue. Increases in elk movements and distribution would become more frequent and would occur earlier in this alternative than in others where feeding was decreased. During the approximately five-year phaseout of supplemental feeding on the refuge and elk transition to greater use of native range, the U.S. Fish and Wildlife Service and the National Park Service would work with the Wyoming Game and Fish Department to resolve co-mingling issues.

As in Alternative 2, as progressively more elk were recruited into the population and were not supplementally fed during their lifetimes, numbers on the refuge could decrease. Distribution would be wider and movements farther as more elk explored native range off the refuge, although fencing on the southern and southwestern boundaries of the refuge would limit movement in these directions. Results of modeling (Hobbs et al. 2003) indicate that elk could winter in areas such as the Gros Ventre River drainage, south of Jackson in the Snake River Canyon, lower portions of Hoback Canyon, Buffalo Valley, and the Gros Ventre River drainage. Some could also discover and use the Gros Ventre feedgrounds, increasing densities near the feedgrounds. In above-average and severe winters, more elk could follow the environ-
mental gradient to the refuge, which is at a lower elevation than the park and the adjacent national forest and would have less snow. If elk attempted to move to potential winter range south of Jackson Hole in the Snake River Canyon or in lower portions of the Hoback Canyon, many could be stopped by feedgrounds in these areas.

Forage enhancements in the Gros Ventre River drainage and Buffalo Valley by the Wyoming Game and Fish Department, the U.S. Forest Service, and other partners, which would begin in the short term, would provide additional forage, attract elk to improved areas, and allow more elk to subsist on native range.

Elk densities on the refuge would gradually decrease as elk numbers were reduced below baseline conditions and distribution became more dependent on standing forage rather than feedgrounds. Cultivated fields on the refuge would continue to attract elk. During snow-crusting periods, mechanical means would be used to increase elk access to and use of cultivated areas with high forage production.

A short-term, early season harvest on the southern portion of the refuge, or public access, would further increase elk movements and distribution away from this traditionally safe area and toward areas to the north and east, at least temporarily. These elk, primarily from the Grand Teton segment, might move to the northern part of the refuge, or perhaps north and east into Bridger-Teton National Forest.

Elk movements and distribution would be negligibly altered by a variety of exclosures in both the short and long terms to protect cottonwood and aspen. Although these exclosures would prevent access to approximately 3% of available acreage on the refuge (approximately 700 acres), densities would decline due to fewer elk compared to baseline conditions and Alternative 1, mitigating this loss.

Distribution of elk among the four herd segments could change, as elk in the park segment would be particularly targeted for harvest.

Late in the short-term period, brucellosis vaccination could occur if safe vaccines were developed with a minimum efficacy of 50% for both bison and elk and could be delivered ballistically or orally. Both forms of delivery could be administered in the park or the refuge. Ballistic vaccination would cause negligible to minor, short-duration increases in movements and distribution, similar to effects described in “Distribution and Movements of Elk” under Alternative 3. If a sufficiently effective oral vaccine was developed that would be safe for elk and bison as well as non-target species, and deliverable through localized food supplementation, vaccine delivery could temporarily change distribution by a negligible to minor extent.

Long-term Effects

The elimination of winter supplemental feeding would continue to influence elk movements and distribution in the long term. During all years fewer elk would remain on the refuge and more would winter on native range. Vegetation exclosures on the refuge would continue to cause minor changes in elk movements and distribution. Prescribed fires on the refuge and the park would continue in the long term to attract elk to treated areas, as under baseline conditions and Alternative 1. Outside the park and the refuge, the U.S. Forest Service, the Wyoming Game and Fish Department, and other partners would continue to enhance habitat in Bridger-Teton National Forest east of the refuge in the Gros Ventre River basin and in Buffalo Valley, which would increase elk distribution in those areas. Some elk could wander farther into the Gros Ventre River drainage, discover WGFD feedgrounds, and increase densities there. Effects from successful land acquisition within refuge boundaries could increase available winter habitat.

Moderate to major declines in densities on the refuge would occur when elk numbers were approximately 2,400–2,700. Later, when vegetation objectives had been achieved and elk numbers increased to 2,800–3,200, densities would be increased by a negligible to moderate amount. On average, densities on the refuge would be decreased to a moderate (50%) degree. The bulk of this decrease in numbers would be borne by the park segment of the herd, which would experience moderate or major decreases. The other segments would experience minor decreases in density and numbers. Short-duration feedline concentrations of approximately 500 elk per acre would no longer occur.
If, in the long term, the southern part of the park and the northern portion of the refuge were closed to hunting, elk movements and distribution would increase in these areas in the fall and perhaps in the winter as well as in other areas until or unless snow crusting and/or depths caused them to move to other areas with better access to forage. If standing forage on the refuge was deemed adequate for objective numbers of wintering elk and bison, cultivated fields could be converted to native habitat and would not attract elk and bison to the same extent they do now.

Elk in the park segment would be the most likely to continue wintering on the refuge. This is in part because their migration is shorter and they are less likely to discover alternative winter range. Elk in the other segments would be more likely to find winter range as they migrated south and southwest from summering areas in southern Yellowstone National Park, the Teton Wilderness, and the Gros Ventre River drainage. The Wyoming Game and Fish Department might be able to adjust hunting strategies in order to help these elk find and stay on newly enhanced winter range outside the refuge (Kilpatrick, pers. comm. 2003).

**Elk Behavior, Social Interactions, and Nutrition**

**Short-term Effects**

Aspects of Alternative 6 that would influence elk behavior, social interactions, and nutrition in the short term include reductions in elk and bison numbers on the refuge, gradual reductions and elimination of supplemental feeding on the refuge, changes in hunting practices, and possible brucellosis vaccination. Habitat enhancements off the refuge and the park and changes to irrigation and farming practices on cultivated areas of the refuge would also affect elk nutrition.

Relatively rapid reductions in supplemental feeding and numbers of elk and bison would result in fewer competitive social interactions associated with feedlines. Interactions common on feedlines would be much less prevalent during non-feeding years, although competition over standing forage would increase in these years compared to baseline conditions and Alternative 1.

The nutritional status of elk could be reduced in some years as the phaseout of winter feeding began. Although reductions would occur first in the mildest winters when vegetation would remain accessible due to relatively little snow cover, the number of feeding years would be reduced as quickly as possible, with the goal of eliminating feeding in five years. In the early years, nutritional status would remain high and would be negligibly affected by the lack of feeding. As supplemental feeding occurred in fewer winters and elk relied on standing forage during increasingly severe winters, nutritional status could be decreased, depending on winter severity and access to forage. The continued production of standing forage could help mitigate this, and impacts to nutrition in the short term might be only negligible or minor.

Exclosures of 700 acres on average and reductions in the number of elk on the refuge would help reduce foraging on woody vegetation in this alternative, particularly in mild winters. Exclosures would negligibly reduce amounts of herbaceous vegetation available to elk compared to baseline conditions and Alternative 1.

If an effective brucellosis vaccine was developed, vaccination activities would cause negligible to minor short-duration adverse effects due to the disruption of normal elk behavior. If the vaccine was delivered ballistically, elk could experience increased nervousness and excitability. Energetic expenditures from running and aggressive social interactions and displacements would increase. Delivery of an effective oral vaccine in supplemental feed would temporarily change distribution in the herd if it was not otherwise a feeding year. Changes in elk distribution and densities at vaccine delivery sites could cause short-duration, localized increases in aggressive social interactions.

**Long-term Effects**

During shortages of native forage, aggressive social interactions involving food competition with other elk and bison could increase.

Competition for forage in winter habitat would increase under Alternative 6 compared to baseline conditions and Alternative 1. Wider ungulate distribution and reduced numbers would partially mitigate increases in forage competition.
The displacement of elk by bison would continue to occur on the refuge, but broader distributions of elk and bison would diminish competition between these two species more than under Alternative 1, where bison numbers would not be controlled.

Nutritional status under Alternative 6 would more closely mimic free-ranging, non-fed elk populations. Impacts would be similar to Alternative 2, but less severe because of bison reductions. There could be more malnutrition, increased use of woody vegetation in severe winters, and moderate to major increases in mortality in severe winters compared to negligible levels under baseline conditions. Although some elk might die during above-average and severe winters because of decreased nutrition and body condition, at low numbers most might be able to maintain adequate nutritional levels on native forage. Continued production of forage on the refuge for 15 years or more and habitat enhancement of areas outside the refuge would help in this regard.

Initiation of supplemental feeding would be based on assessments of forage utilization (done jointly by WGFD and NER personnel) and potentially on the January 1 index of winter severity calculations for elk (Farnes, Heydon, and Hansen 1999). In addition, ration or pellet composition might need to be changed to allow for later initiation of supplemental feeding. A higher fiber formula, as recommended by Baker and Hobbs (1985) for mule deer, might be one possibility.

Vaccination activities, if an oral vaccine was available, would continue to cause negligible to minor, short-duration disturbance, including increased excitability, energetic expenditures, and aggressive interactions.

**Disease Prevalence and Transmission**

**Bovine Brucellosis**

Prevalence in Herd — Under Alternative 6 reductions in density on the refuge and wider dispersion of elk would reduce contact with infected elk, bison, or fetuses and result in major reductions in the prevalence of brucellosis in refuge elk in the long term. Prevalence would likely drop to those typical of unfed populations in the region (e.g., 1%–3%). For the entire herd (of which the refuge elk are a portion) there would only be a moderate long-term reduction in prevalence because approximately 2,500 elk would continue to be fed on the state-operated Gros Ventre feedgrounds. Brucellosis prevalence could decrease by a minor to moderate amount if a safe vaccine with an efficacy of 50% or better is developed and could be delivered ballistically or orally to a free-ranging herd. The extent of decrease would depend on the number of elk vaccinated and the vaccine’s efficacy.

Transmission among Elk — Impacts to transmission would be similar to those in Alternative 2. Disease management experts indicated the probability of transmission would be reduced by a moderate amount in the short term and a major amount in the long term compared to Alternative 1. This would be likely for Alternative 6 as well. A similar, minor to moderate reduction in transmission among elk in the entire herd unit would be likely.

Transmission from Bison to Elk — Because of increased dispersion outside the refuge, lower numbers of both bison and elk on the refuge, and lower numbers of bison overall, there would be a major reduction in transmission of brucellosis from bison to elk on the refuge.

**Septicemic Pasteurellosis**

Impacts from this disease under Alternative 6 would be most similar to those under Alternatives 2 and 3 and lower when compared to all other alternatives. For more detailed discussion, see the corresponding section for elk under “Disease Prevalence and Transmission” in Alternative 1.

**Necrotic Stomatitis and Footrot**

An increased incidence of necrotic stomatitis in the Jackson elk herd could occur if sufficient high quality forage was not available and elk were forced to use poor forage, such as coarse woody vegetation. This could be the case in Alternative 6, especially before elk numbers were decreased and during the phasing out of winter feeding. Therefore, negligible to minor increases similar to Alternative 2 would be possible.
The prevalence of footrot would be lowest under Alternative 6 (as well as Alternative 2) because supplemental feeding would be eliminated.

*Psoroptic Scabies*

Winter feeding results in direct contact between elk, increasing the chance for transmission of psoroptic mites. Prevalence of psoroptic scabies in the Jackson elk herd would therefore decline under Alternative 6, a minor benefit compared to Alternative 1.

*Helminths and Lungworms*

Lungworm transmission and prevalence in the elk herd would be lowest under Alternative 6 (similar to Alternative 2) because winter feeding would be reduced and eventually eliminated. Lungworm transmission among elk and prevalence in the elk herd would be higher under Alternatives 3 and 4, and would be greatest under Alternatives 1 and 5 because winter feeding would occur nearly every year, or every year, and high elk numbers would be maintained.

*Bovine Tuberculosis and Paratuberculosis*

Bovine tuberculosis and bovine paratuberculosis are not present in the Jackson elk herd. Although analyzed here, bovine paratuberculosis has only been reported sporadically in elk and should be considered primarily a disease of bison (Roffe, pers. comm. 2005). The relative risk among the alternatives that either of these diseases would become established would be lowest under Alternatives 6 and 2 because the winter feeding program would be eliminated. See the discussion for elk under impacts of Alternative 1, “Disease Prevalence and Transmission,” for more details. Should either disease become established, potential prevalence would be initially moderately lower compared to Alternative 1, but reduced by a major amount in the long term because the feeding program would be eliminated and elk numbers reduced.

*Malignant Catarrhal Fever*

There are no reports of malignant catarrhal fever occurring in the Jackson bison or elk herds (Hayden-Wing and Olson 2003), and the most effective control of infection risk would be to prevent susceptible species from contacting reservoir hosts (e.g., domestic sheep).

If elk or bison left Jackson Hole, they would have a greater chance of coming into contact with domestic sheep herds and potentially contracting the virus. Hence, the risk of contracting malignant catarrhal fever would be greatest under Alternatives 2 and 3 because historical elk migration routes could be reestablished and elk and bison could disperse from the refuge during winter. The risk under Alternative 6 would be higher than under Alternatives 1, 4, and 5 because winter feeding would be eliminated and elk would disperse. If the disease became established, the potential for spread would be lowest under this alternative because supplemental feeding would be phased out quickly.

*Chronic Wasting Disease*

The risk of chronic wasting disease being introduced into the Jackson elk herd under Alternative 6 would be lower than under Alternative 1 because risk would be greatest under alternatives with the highest elk numbers (Alternatives 1 and 5), somewhat less under Alternative 4, and lowest under Alternatives 6, 2, and 3. If high numbers of elk dispersed onto summer range, and if some elk wandered beyond the designated herd unit area, these elk would have a higher potential of contracting the disease. If increased dispersion occurred under Alternative 6, the risk of introduction would increase.

Potential prevalence and transmission of chronic wasting disease under Alternative 6, should it become established, would likely be similar to what would occur under Alternative 2 and lower than all other alternatives (see Table 4-6).

*Calving, Age and Sex Ratios, and Recruitment*

*Short-term Effects*

Age and sex ratios would initially be similar to baseline conditions and to those expected under Alternative 1, but ratios would likely change somewhat under Alternative 6 due to increased winter mortality and hunting. Eliminating supplemental feeding would be more likely to increase mortality in older animals or calves, as well
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as some prime bulls entering the winter energetically stressed due to rut activities.

**Long-term Effects**

Because numbers would be reduced and forage production would continue (for at least 15 years), winter mortality rates would likely decrease. Brucellosis related deaths in calves would also decline, with minor to moderate benefits to refuge elk, although this would only make a negligible contribution to production and recruitment in the herd.

Impacts on production and recruitment from septicemic pasteurellosis under Alternative 6 would be similar to those under Alternatives 2 and 3 and lower than under all other alternatives.

Adverse impacts on production and recruitment from necrotic stomatitis in the Jackson elk herd would be similar to prevalence, that is, negligible, under Alternative 6 compared to Alternative 1.

Adult bull mortality from psoroptic scabies would decrease negligibly under Alternative 6.

The potential number of clinical cases of bovine tuberculosis and paratuberculosis, if either disease infected the herd, would be substantially lower under Alternative 6 compared to Alternative 1. Production losses would be lower be a major amount over time. However, the absolute impact of these diseases on production in the herd would be low. As an example, if prevalence of bovine tuberculosis or paratuberculosis was 50%, and 5% of those developed clinical disease, then a maximum of 2.5% of the potential calf production could be retained; this would constitute a negligible increase in production and recruitment.

Impacts from chronic wasting disease would be caused indirectly through changes in mortality, the level of which would depend on prevalence in the herd. Experts believe prevalence would lie between levels found in free-ranging (4% on average) and confined elk (up to 59% or higher). Relative impacts on production and recruitment under Alternative 6 would be similar to those under Alternative 2 and less than under Alternative 1 as well as Alternatives 3, 4, and 5 (see Table 4-6). Rankings were based on winter feeding frequency and duration, as well as on the number of elk wintering on the refuge.

**Mortality**

**Short-term Effects**

Winter mortality would gradually increase under Alternative 6 as supplemental feeding was reduced and elk relied more and more on standing forage, especially if the fence at the southern and southwestern sides of the refuge prevented access to some native winter range. Mortality rates would not be expected to rise on native winter range, but because the number of elk on native winter range would increase (as opposed to being supplementally fed), the number of elk subject to higher mortality would increase.

As feeding was slowed or stopped, elk particularly from the park segment could seek food on private land in the area and be subject to removal by the Wyoming Game and Fish Department. Elk from other segments would likely find wintering areas to the northeast and east of the refuge, and few management removals would be necessary. Increases in movements and distribution could increase the number of elk deaths from vehicle collisions.

During the approximately five-year phaseout of supplemental feeding and transition to native range, the U.S. Fish and Wildlife Service and the National Park Service would work with the Wyoming Game and Fish Department to resolve co-mingling issues.

Harvest mortality during the short term would be increased compared to baseline conditions and Alternative 1. As supplemental feeding was reduced, the number of elk outside the refuge during hunting season could increase, and more elk could be available to hunters on national forest lands.

As refuge elk density decreased, fewer brucellosis-caused abortions (which currently reduce potential births by an estimated 5%) would occur, partially mitigating increases in mortality.
Elk mortality would be expected to be higher in the long term than all alternatives except Alternative 2. Levels would be greater than the 1%–2% per year under baseline conditions and Alternative 1, but the high end of the range would likely be less than the potential 23% in severe winters estimated under Alternative 2 (17% if 2,500 elk were supplementally fed at the Gros Ventre feedgrounds; Hobbs et al., 2003). Lower numbers of elk wintering on the refuge and enhanced forage production would reduce the extent of mortality in these years.

Mortality from starvation, and from predation and disease related to poor body condition, would continue to increase as supplemental feeding was phased out. Reductions in the bison population, closure of some existing areas to elk hunting, and improvement of habitat outside the refuge would help mitigate mortality. Winter mortality would reflect winter severity, ranging from very low during mild winters to high during severe winters (B. L. Smith, pers. comm. 2002; Hobbs et al. 2003).

The Wyoming Game and Fish Department anticipates increased conflict between elk and non-agricultural landowners, with depredations to ornamental shrubbery, horse hay, and increased vehicle collisions in and around subdivisions (Holz, pers. comm. 2003). In the long term management removals because of these conflicts would decline as population numbers declined.

Health, Sustainability, and Naturalness

Short-term Effects

The health and sustainability of the Jackson elk herd would increase as supplemental feeding was eliminated and elk relied more and more on standing forage (both native and cultivated). Alternative 6 would be similar to Alternative 2 in terms of health and sustainability. With the elimination of winter feeding, wider distribution, and reductions in bison and elk numbers, lower ungulate concentrations would result in lower disease prevalence and transmission of current diseases such as brucellosis, as well as of any non-endemic infectious disease. Alternative 6 (and Alternative 2) would lower the risk of future population declines or depopulation events from bovine tuberculous pasteurellosis under Alternative 6 would be similar to that under Alternative 2 and lower than under all other alternatives.
Impacts on the Jackson Elk Herd: Impacts of the Alternatives — Alternative 6

culosis, for example, or other non-endemic disease.

Herd health would also increase if a safe brucellosis vaccine was developed with an efficacy of 50% or better that could be delivered orally or ballistically to a free-ranging herd and if bison were vaccinated. Vaccination and its effects could occur in the short term whenever these conditions were met.

Barring the introduction of a serious non-endemic disease, the elk herd would continue to be self-sustainable and maintain genetic viability at a size of approximately 9,300–11,000 after the refuge portion of the herd was reduced to the objective level.

Naturalness would also increase in the short term under Alternative 6 as elk increasingly dispersed as they sought available forage on native range, and environmental factors, such as winter weather and predators, would have an increasingly stronger influence on mortality. Mortality would increase in some winters and more closely approximate mortality in non-fed herds. These effects would be similar but more limited than under Alternative 2. Fewer of these human-related deaths might occur when elk numbers were at objective levels.

Long-term Effects

These same trends would continue in the long term. Lower numbers would eventually allow elk to subsist on native range, lowering the risk of transmitting existing or new diseases. Herd size would be maintained at 9,300–11,000, and mortality would approximate that in unfed populations.

Harvest would be adjusted to allow some natural fluctuations in herd size while maintaining the objective. Exchanging nearly annual supplemental feeding with foraging on native vegetation, along with increased overwinter mortality of the less fit, could be expected to increase the overall fitness of the herd (Mills, pers. comm. 2003). Impacts to fitness would likely be subtle and would take many years to affect a population (McDonald, pers. comm. 2003; Boyce, pers. comm. 2003).

Long term health and sustainability of the elk herd under Alternative 6 would be similar to these qualities under Alternative 2 and higher than under all other alternatives.

Naturalness would increase in the herd. Production and recruitment rates would be more natural, and calves born outside the normal birthing season would be less likely to survive. Winter mortality would be more natural due to the lack of a winter feeding program on the refuge, with mortality rates differing among age and sex classes in a more natural way. Elk would distribute themselves more naturally, expend more energy accessing winter forage, and maintain a more natural, lower nutritional status. Elk behavior would also become more natural. Competitive social interactions and displacements associated with feedlines would be eliminated.

Harvest quotas in the long term would strive to maintain sex ratios of approximately 35 bulls to 100 cows in the park segment, as under Alternatives 3, 4, and 5. Sex ratios of the Jackson elk herd as a whole would be similar to ratios under baseline conditions and Alternative 1. Possible increases in elk distribution could cause more animals to be killed by vehicles or agency removals, but these increases in mortality would be negligible.

Alternative 6 would result in a higher level of naturalness in the elk herd than would Alternatives 1, 3, 4, 5. Naturalness would be similar to Alternative 2 because of the elimination of winter feeding.

Conclusion

In the long term under Alternative 6 the Jackson elk herd would have an estimated 9,300–11,000 elk, and fewer elk would winter on the refuge. The elk herd would increase its movements and distribution and increased winter mortality would occur.

The risk of a non-endemic infectious disease quickly spreading through the population or having major adverse impacts to elk survival would be among the lowest of all the alternatives because of eliminating contact associated with the feedlines, reduced numbers, and increased dispersion. The prevalence of brucellosis in the Jackson elk herd would be moderately lower than under Alternative 1.
After supplemental feeding was stopped, the herd would be more responsive to natural conditions and winter mortality would fluctuate with winter severity, precipitation regimes, and standing forage on native range, similar to Alternatives 2 and 3. Recruitment and annual survival would be close to levels found in non-fed populations in similar environments. Alternative 6 (along with Alternative 2) would result in higher levels of long-term health, sustainability, and naturalness in the Jackson elk herd than what would occur under Alternatives 3, 4, and 5.

Barring the introduction of serious non-endemic disease, Alternative 6 would not impair the elk population in the park. Alternative 6 (along with Alternative 2) would have the lowest potential for impairment from disease.

MITIGATION

Several measures have been built into the alternatives to mitigate reductions in winter feeding on the refuge, including continued flood irrigation (Alternative 3, Option A), improved forage quality on the refuge’s cultivated fields (Alternative 6), restoration of winter range in Bridger-Teton National Forest (Alternatives 2, 3, and 6), and establishment of migrations to winter range outside the Jackson Hole area (Alternatives 2 and 3). Another measure that would mitigate reduced elk numbers discussed in some alternatives would be the potential use of conservation easements to allow elk grazing on private lands or to reduce conflicts between elk and livestock and payments to landowners to have elk graze on their property rather than grazing and wintering livestock on the property.

CUMULATIVE EFFECTS

TRANSPORTATION IMPROVEMENTS

The reconstruction of U.S. 26/287 west of Togwotee Pass would cause short-term disturbance and displacement of some Jackson elk during construction stages and could affect elk migration in the Buffalo Valley area. The reconstruction would disturb about 16 acres of “crucial elk habitat” along the existing road corridor and could increase elk mortality due to vehicle collisions as a result of greater traffic volume. Along some portions of the highway the project retaining walls, guardrails, and passing lanes would also create both short- and long-term movement barriers. Long-term impacts would be somewhat greater due to the generally wider highway and the presence of retaining walls and guardrails in some areas. Upgrading the existing highway would be unlikely to result in extensive effects in terms of blocking migration routes or movement corridors. It is anticipated that effects on overall herd dynamics would be minimal.

Cumulative effects would not occur under Alternatives 1 and 5 because elk distribution, seasonal movements, and mortality rates would remain similar to baseline conditions. Alternative 4 could result in negligible cumulative effects if elk mortality rates increased in average winters. Under Alternatives 2, 3, and 6 more elk would use native winter range, and the Jackson elk herd would be smaller in some years due to higher mortality compared to Alternatives 1 and 5.

FEDERAL LAND MANAGEMENT ACTIVITIES

Grand Teton National Park Fire Management

Mechanical treatments could result in a small reduction in elk habitat, reduced habitat quality, and short-term disturbance effects that could displace more mobile animals in proximity to Wildland Urban Interface (WUI) areas. However, these actions are not expected to adversely affect elk at a population level because habitat effectiveness in these areas and the immediate vicinity has already been reduced. WUI areas represent a small part of habitat available to park wildlife, and the vast majority of wildlife habitat in Grand Teton National Park occurs outside developed areas.

Prescribed fire could be used to maintain and restore more diverse vegetative communities in landscapes where natural fire regimes have been disrupted. Prescribed fires could alter plant communities and displace individual elk from certain portions of habitat in the short and long terms, but the long-term effects could create vegetative diversity that favors native wildlife species.

Alternative 1 would not result in cumulative effects as a result of Grand Teton National Park fire management. Alternatives 2–6 would convert formerly cultivated areas in the southern portion of
the park to native vegetation. These conversion activities could disturb and displace elk from nearby habitat in the short term if elk were present, adding to short-term habitat losses. These activities would likely affect few elk because they are widely dispersed in the park during the summer.

Eliminating the elk reduction program in the park under Alternative 2 could result in more elk remaining in the southern portion of the park, thereby increasing the number of elk that were affected by the short-term effects of prescribed fires. Closing the Antelope Flats/Blacktail Butte elk reduction area in the park under Alternative 3, and potentially under Alternative 6, could also result in this effect, but to a lesser extent. Since fewer elk would be present in the park during the summer under these alternatives than under Alternatives 1, 4, and 5, this effect might not occur. Any cumulative effects would be relevant to elk affected by short-term disturbance and loss of habitat due to Grand Teton National Park recreation infrastructure improvements.

**Grand Teton National Park Recreation Infrastructure Improvements**

The proposed implementation of multi-use pathways, the realignment of portions of the Moose-Wilson Road, and other transportation improvements would result in site-specific, temporary impacts along planned construction routes during the summer. The completed trail component would attract additional recreationists along the Snake River corridor during the summer and possibly cross-country skiers in the winter. The trail construction phase would likely displace elk within or near work areas in the short term and make habitat unavailable. If pathways were separate from existing roads, long-term impacts to elk could include loss of habitat, loss of the use of habitat near the new pathways, and changes in movements and distribution. Improved human access to parts of the park could increase levels of disturbance to elk and alter distribution and habitat use.

Any future improvements to the Gros Ventre campground would result in site-specific, temporary impacts during construction and would result in a minor increase in the number of summer campers and the potential for elk to be displaced. The improvements would increase disturbance to elk in summer and alter distribution and habitat use; effects would likely be negligible because habitat effectiveness in these areas is already reduced.

Alternative 1, in combination with the effects of Grand Teton infrastructure improvements, would not result in cumulative effects. Alternatives 2–6 could result in additional elk disturbance with some displacement as a result of infrastructure improvements because of greater human presence in southern portions of the park during the conversion of formerly cultivated areas to native vegetation.

Eliminating the elk reduction program in the park under Alternative 2 could result in more elk remaining in the southern portion of the park, increasing the potential for additional disturbance and the displacement of elk from suitable habitat. Closing the Antelope Flats/Blacktail Butte elk reduction area in the park under Alternative 3, and potentially under Alternative 6, might also result in this effect but to a lesser extent. Because fewer elk would be present in the park during the summer under these alternatives than under Alternatives 1, 4, and 5, this effect might not occur.

**Grand Teton/Yellowstone National Parks and John D. Rockefeller, Jr., Memorial Parkway Temporary Winter Use Plan**

Throughout the analyses in the *Temporary Winter Use Plan Environmental Assessment*, the assumption was made that any effects of oversnow vehicles and winter recreation on wildlife would be exacerbated during severe winters due to increased energetic costs and chronic, severe under-nutrition. Impacts on elk from winter use would vary from none to adverse and moderate. The total number of snowmobiles allowed into the park would be similar to historical levels, but because all visitors would be traveling in guided groups, oversnow vehicles users would be less likely to interact with wildlife, resulting in fewer disturbances to elk.

Compared to historical conditions, beneficial impacts on all facets of interactions between wildlife and oversnow vehicles would occur. While the total number of oversnow vehicles allowed in the parks would approximate the historical average,
all users would be led by professional guides, who
would be trained how to avoid causing wildlife
displacement or stress, and who would be familiar
with likely wildlife locations along the road sys-
tem. Under such conditions, oversnow vehicles
would be less likely to interact with wildlife, re-
sulting in less mortality, less stress, less dis-
placement, and fewer population-level impacts.
The impacts would not be of sufficient magnitude
to adversely affect elk.

No impacts to elk in adjacent national forest and
other lands outside the park are anticipated. Be-
cause the selected alternative would allow a num-
er of snowmobiles into the parks that are near
the historical average daily visitation, it would be
unlikely to result in significant visitor displace-
ment to surrounding federal, state, or county land,
except during high use periods (Christmas week
and Presidents Day weekend).

Alternatives 1 and 5, and Alternative 4 in above-
average winters, would not result in cumulative
impacts on elk from planned winter use activities.
Alternatives 2, 3, and 4 in average or below aver-
age winters, as well as Alternative 6, would in-
crease the number of elk on native winter range.
When combined with winter use, this could result
in more displacement of elk from winter habitat.
Elk in areas designated as crucial winter range
would not be affected because closures would con-
tinue.

Bridger-Teton National Forest Fuels Management
Projects

Bridger-Teton National Forest has identified a
variety of fuel reduction and habitat enhancement
projects in the primary and secondary analysis
areas. These projects would alter about 9,400
acres of national forest land and could temporarily
diminish forage opportunities directly following
various fuel reduction treatments. However, in
the long term most of these projects would im-
prove elk transitional and winter habitat.

Cumulative effects of thinning projects on the
Jackson elk herd would vary among the alterna-
tives considered for bison and elk management.
Because of reduced or eliminated winter feeding
on the refuge, Alternatives 2, 3, and 6 would re-
sult in more elk wintering on native range and
potentially moving into project areas. Some elk
could experience diminished foraging opportuni-
ties in the short term if they arrived while or
shortly after project activities had occurred. In
the long term enhanced forage in these areas
would benefit elk. These projects would benefit
fewer elk under Alternatives 1, 4, and 5 because
winter supplemental feeding would continue to
attract elk to the refuge and limit their distribu-
tion. Some Jackson elk would benefit from pro-
jects in transitional habitat under all alternatives,
although to a lesser degree than under Alterna-
tives 1 and 5. The Moose-Gypsum projects and the
Green River Lakes campground project would
only affect elk that had dispersed into the sec-
dary analysis area under Alternatives 2, 3, and
potentially 6.

Bridger-Teton National Forest Travel Manage-
ment Plan Updates / Moose-Gypsum Projects

The proposed Moose-Gypsum travel management
projects in the secondary analysis area would al-
ter existing elk habitat, including elk winter range
in the secondary analysis area. The proposed pro-
jects could temporarily diminish forage opportuni-
ties in some areas due to reductions in forage ar-
eas directly following various fuel reduction treat-
ments and increased off-highway vehicle opportu-
nities. However, in the long term the proposed
projects could result in enhanced forage for elk
due to the regeneration of nutrient-rich under-
growth. These projects could result in cumulative
effects on Jackson elk that could disperse into the
upper Green River watershed under Alternatives
2, 3, and potentially 6 by reducing the availability
of forage in some areas.

The Moose-Gypsum projects could establish new
campsites while closing campsites that are in sen-
sitive areas, such as next to stream and river
banks. Establishing new campsites could increase
the potential for human/elk interactions in the
short term, although closing other sites would
offset this increase. Closing sites in sensitive ar-
eas would decrease the potential for interactions
that could disturb and displace elk from more
critical habitat. In the long term these projects
could result in beneficial cumulative effects to
Jackson elk that could disperse into the upper
Green River watershed under Alternatives 2, 3,
and potentially 6.
BLM Snake River Resource Management Plan

Greater public access or use in areas of sensitive wildlife habitat, including overnight camping, would likely increase the potential for detrimental, direct effects to vegetation and forage, and/or increased conflicts between humans and wildlife. Impacts to elk forage could occur if livestock grazing was allowed by the acquiring or managing agencies or entities. Continued management of conservation easements for open space and wildlife habitat would protect elk migration routes, corridors, and habitat. Pursuit of a long-term protective withdrawal to prohibit the staking and development of mining claims would also benefit elk by preventing potential adverse impacts to foraging or wintering habitats.

No cumulative effects would be expected under Alternatives 1 and 5 because these alternatives would not affect the amount of disturbance to elk or increase the potential for encounters. Alternatives 2, 3, and 4 in average or milder than average winters, as well as Alternative 6, would increase elk distribution in some years and the potential for disturbance due to human encounters, although seasonal closures would mitigate this potential increase.

BLM Upper Green River Special Recreation Management Area Recreation Project Plan

Projects considered in the Recreation Project Plan would affect a total of about 16.5 acres (less than 1% of the total management area), excluding the main road resurfacing. Construction activity is not anticipated to impact wintering Jackson elk in the upper Green River watershed.

None of the bison and elk management alternatives being considered in this environmental impact statement would result in cumulative effects on the Jackson elk herd. Although some Jackson elk could move into the upper Green River area to winter under Alternatives 2, 3, and possibly 6, these animals would not be expected to remain in other seasons.

Pinedale Anticline Oil and Gas Exploration and Development Project

Oil and gas development activities in the Pinedale anticline project area are not anticipated to specifically impact elk populations. Seasonal restrictions and other measures would be implemented to minimize impacts to other big game populations. None of the proposed bison and elk management alternatives would contribute measurably to these effects and would not result in cumulative effects on elk in the Pinedale anticline study area.

Snake River Restoration Activities

Construction of the Snake River restoration measures by the U.S. Army Corps of Engineers could impact habitat for a variety of wildlife species, including elk migration corridors, along the river. This environmental restoration project would prevent further degradation of habitat and facilitate habitat recovery. To avoid conflicts with migrating elk, the environmental assessment states that work should cease by November 15, unless prior coordination with the Wyoming Game and Fish Department has taken place. Improvements in water quality and elk habitat along the Snake River would continue to benefit elk in the long term.

Cumulative effects would not be expected to occur under Alternatives 1 and 5 because these alternatives would not increase or alter elk distribution or the potential for disturbance. Alternatives 2, 3, and 4 in average or milder than average winters, as well as Alternative 6, would increase elk distribution in some or all years and the potential for disturbance in the short term due restoration activities. Restricting the work season would decrease the potential for disturbance, displacement from habitat, and changes to migrations.

Population Growth and Private Land Development

Primary Analysis Area

Projected population increases in both Teton and Sublette counties would continue to create a demand for private land development. Habitat loss, increases in elk/human encounters and conflicts, vehicle collisions with elk, and changes to elk movements could occur.

Additional development that is near or adjacent to the Snake River would be subject to the Natural
Resource Overlay (NRO) zoning district requirement (see Chapter 1, “Reasonably Foreseeable Actions”), which would help sustain elk migration in those areas by protecting migration routes and crucial winter ranges. Residential development of the platted and zoned parcels within the primary analysis area to the south and west of the Jackson Hole Airport has greatly reduced the potential for elk migration between Grand Teton National Park, summer habitat on private lands, and the National Elk Refuge south of Moose.

Two narrow corridors of open land near Gros Ventre Junction might sustain the major east-west migration in the Jackson Hole Airport area. The northernmost area is protected by conservation easements, while the narrow corridor to the south is partially included in the NRO district and appears to be a private open space component of the Bar-B-Bar Meadows subdivision. These protected lands might continue to support a migration corridor through the area, though it is not known whether they would provide sufficient habitat to sustain such a corridor for the long term.

Additional development on private lands in the Buffalo Valley area would be outside or on the perimeter of elk winter range, and would be subject to NRO district requirements. Such development, if it occurred, would not be expected to adversely affect elk use of the winter range in the area.

Alternatives 1 and 5, as well as Alternative 4 in above-average and severe winters, would not alter elk distribution and migration or result in cumulative effects. Alternatives 2, 3, and 4 in average or milder than average winters, and potentially Alternative 6, would increase elk distribution in some or all years, and human population growth and development would likely affect more elk under these alternatives. NRO zoning district requirements would decrease the likelihood of adverse effects.

Additional development of the private parcels along the Gros Ventre River could affect the movement of elk between Jackson Hole and existing feedgrounds to the east. Under Alternatives 2, 3, and potentially 6, undeveloped portions of this corridor would support the movement of elk between Jackson Hole and the upper Green River basin to the southeast. Additional development along the Gros Ventre River could also adversely affect these movements.

**Secondary Analysis Area**

Within the secondary analysis area in Sublette County, ongoing and future subdivision and development of agricultural lands could disrupt migration routes and reduce the availability of elk winter range in the upper Green River valley. Development or activities in these areas would not affect Jackson elk under Alternatives 1, 4, and 5 because elk movements and distribution either would not increase from current distribution (Alternatives 1 and 5) or would increase to a limited extent in some years (Alternative 4).
This section describes the effects of the alternatives on bison numbers, distribution, movements, calf production, mortality, and the health of the Jackson bison herd. It also identifies and explains the factors that would influence the population and that would lead to the population effects described below.

**METHODOLOGY USED TO ANALYZE EFFECTS**

The same methodology as described for impacts on elk was used for impacts on bison.

As previously described, under all alternatives except Alternative 2 the U.S. Fish and Wildlife Service and the National Park Service would work cooperatively with the Wyoming Game and Fish Department to achieve population objectives, including herd ratios, the determination of hunting seasons, and the evaluation of hunt areas. The Wyoming Game and Fish Department would formally establish objectives and strategies after public review and approval by the Wyoming Game and Fish Commission.

When comparing impacts of Alternatives 2–5 to Alternative 1, it was assumed that the growing bison population under Alternative 1 would remain on the refuge during winter because the feeding program would encourage them to stay there.

The primary actions under the management alternatives that could play a role in influencing disease prevalence and transmission in the Jackson elk and bison herds are summarized in Table 2-4 (page 81). The impact analysis assumes that winter feeding would have been fully phased back to anticipated levels prior to a non-endemic disease being introduced into the elk or bison herd.

Total numbers of Jackson bison and those wintering on the refuge would be essentially the same, except for the very few bison that remained on native winter range and did not migrate to the feedgrounds on the refuge.

The analyses are quantitative wherever data allowed. Where sufficient numeric information was not available, qualitative or relative assessments were made. Impact levels, as defined during the disease expert meeting, would be the same as for elk (see page 256).

Discussion of direct, indirect, secondary, short-term (less than 5 years), long-term (15–20 years or longer), and cumulative impacts are included as appropriate.

**IMPACTS OF THE ALTERNATIVES**

**IMPACTS COMMON TO ALL ALTERNATIVES**

**Disease Impacts**

Although the prevalence of brucellosis would vary among alternatives, brucellosis would not likely be eradicated from the Jackson bison herd under any alternative, even with a highly effective vaccine (Peterson, Grant, and Davis 1991b; Gross, Miller, and Kreeger 1998; HaydenWing and Olson 2003). Measurements of brucellosis seroprevalence in the bison herd range from 58% (84/145 harvested bison; 1999–2003, WGFD unpubl. data) to 84% (110/131, study animal sampling included some non-random age and repeat sampling; 1997–2004, GTNP, unpubl. data). Seroprevalence differences could be due to sampling error, testing methods, and criteria used (Roffe pers. comm. 2003).

There is no evidence that bison are susceptible to the strains of *Pasteurella multocida*, which cause septicemic pasteurellosis in elk. Bison probably do not get the elk strain (Disease Expert Meeting 2002), and septicemic pasteurellosis would not impact the Jackson bison herd under any of the alternatives.

Bison are likely susceptible to other forms of necrobacillosis such as foot rot, but the thorough review of disease literature conducted for this document (Peterson 2003) found no documented cases of necrobacillosis, or necrotic stomatitis, in bison. Necrotic stomatitis would not impact bison and was dropped from further analysis.
CHAPTER 4. ENVIRONMENTAL CONSEQUENCES

Three documented viral microparasites, bovine viral diarrhea, parainfluenza virus-3, and bovine respiratory syncytial virus, were also dropped from further analysis. Seroprevalence for these three viruses can be high in the Jackson bison herd, but no associated clinical disease has been documented in the herd.

Although bison may have their own species of *Psoroptes*, no records of these mites have been reported in the Greater Yellowstone Area. Therefore, psoroptic scabies are not expected to impact bison under any of the alternatives and are not discussed further in this section.

Bison would not be adversely affected by elk lungworms under any of the alternatives. Because lungworms are specific to the particular host species, the risk of interspecies transmission is low (Peterson 2003; Disease Expert Meeting 2002). The lungworm, which is thought to be the most detrimental parasitic helminth known to occur in the Jackson elk herd (Worley 1979; Smits 1991; Peterson 2003), also infects bison, but its prevalence in Greater Yellowstone Area bison herds is unknown (Peterson 2003). Other gastrointestinal parasites and helminths are only incidental in the Jackson bison herd (Peterson 2003), and effects are expected to be minimal under all alternatives. Therefore, these other parasites are not considered in detail in the following analysis.

Vesicular stomatitis, an undocumented viral microparasite, is not analyzed in detail because no impacts are likely in bison (Disease Expert Meeting 2002).

Foot-and-mouth disease and rinderpest are not analyzed in detail because there are no documented records of these viral microparasites in the United States, and if either became established in the United States, the national response would be major and very aggressive (Disease Expert Meeting 2002).

Bison are not susceptible to chronic wasting disease. Based on current information, only elk, mule deer, and white-tailed deer are susceptible (Williams et al. 2002), and it is unlikely that bison would be affected.

There are no impacts at present from bovine tuberculosis, bovine paratuberculosis, or chronic wasting disease. Discussion of potential impacts if these diseases infected the herd is addressed in the context of the effects each alternative would have on transmission and prevalence if one or more of these diseases were introduced.

**Competition for Forage by Livestock Grazing**

Competition for forage between elk, bison, and cattle in Grand Teton National Park, Bridger-Teton National Forest, and some private lands in Jackson Hole, Buffalo Valley, and the Gros Ventre River drainage is discussed under each alternative under “Social and Economic Impacts: Impacts on Livestock Operations, Competition for Forage.”

While competition for forage between bison and cattle would occur to a limited extent in the park, the effect of cattle grazing is negligible for several reasons. The amount of cattle grazing that is permitted is low and continues to decline. In 2005 and 2006 there were only 160 cow-calf pairs in the park, and some allotments were not used. Summer habitat is abundant, and cattle are not grazed on winter range (i.e., they are not in areas where forage is available in the winter).

**ALTERNATIVE 1**

**Analysis**

In the following sections, short- and long-term effects are discussed together unless otherwise noted.

**Bison Numbers**

In the most recent annual Jackson bison herd census and classification, conducted on February 6, 2006, 948 bison were counted. Continued low mortality under this alternative would facilitate rapid herd growth. Average herd growth ranged from 10% to 14% (an average of 10% when the WGFD harvest removed approximately 40–50 bison per year from 2001 to 2004; 14% from 1990 to 2004). Bison numbers, as expected, increased to approximately 1,000 by spring 2006 and may exceed 2,000 by mid-2014 if harvest continues to remove 40–50 bison per year.
Impacts on the Jackson Bison Herd: Impacts of the Alternatives — Alternative 1

Distribution and Movements of Bison

Although the number of bison in this area prior to Euro-American settlement is unknown, bison remains indicate that they were found in the central valley of Jackson Hole, along the Gros Ventre River, the west slope of the Gros Ventre Range, on the National Elk Refuge, and along the Snake River south of Jackson (Fryxell 1928; Ferris 1940; Love 1972). Because these remain represent mortalities in key wintering areas, bison likely inhabited the northern areas of Jackson Hole as well, especially in summer.

The growing bison herd would likely increase its movements and distribution under Alternative 1, moving seasonally between the park and the refuge, and perhaps also using Bridger-Teton National Forest lands and the Gros Ventre River drainage to the east. More bison than under baseline conditions would likely venture onto private lands, including the airport and golf course areas west of the refuge and south of the park and private sections of Buffalo Valley east of the park. These range expansions could be short-lived, however, if the Wyoming Game and Fish Department exercised its prerogative to remove bison on private lands where the animals could threaten human safety and damage property.

Range expansion has been limited to date partly because bison have a strong fidelity to seasonal ranges and forage has not been limiting. As the herd grew to over 700 (its size in early 2004), its range expanded to the east only slightly. In November and December 1998, when there were about 440 animals in the herd, more bison than under baseline conditions would likely venture onto private lands, including the airport and golf course areas west of the refuge and south of the park and private sections of Buffalo Valley east of the park. These range expansions could be short-lived, however, if the Wyoming Game and Fish Department exercised its prerogative to remove bison on private lands where the animals could threaten human safety and damage property.

Factors that would continue to influence winter distribution include greater snow depths and correspondingly smaller amounts of available forage in the park (Farnes, Heydon, and Hansen 1999; Hobbs et al. 2003), irrigation and cultivation practices on the refuge, and long-term supplemental feeding on the refuge. The attraction of easily obtainable, abundant food would continue to restrict bison movements and distribution during winter feeding periods.

Shallower snow depths on the refuge as compared to other parts of Jackson Hole used by bison would continue to attract bison during the transitional and winter seasons. Irrigation and farming practices, including the cultivation of 2,400 acres of the southern part of the refuge and supplemental feeding, would also continue to attract bison southward and possibly decrease the amount of time bison spend in transitional areas in the park and the refuge where native forage is available. A negligible amount of prescribed fire would continue to enhance forage and habitat and attract bison to treated areas.

During supplemental feeding periods, bison disperse to nearby areas after eating at the feedlines to feed on standing forage, and they rest during a large part of the day (Smith and Robbins 1984). If bison numbers grow to 2,000, the average 70-day feeding period might need to be expanded because of over-grazing and forage competition with elk on the refuge. Bison distribution under Alternative 1 would likely encompass the entire southern end of the refuge.

It is expected that harvest would continue to play a limited role in restraining bison herd growth and that the bison population would number an estimated 2,000 by 2014 and would continue to expand their range, primarily to the east.

Bison Behavior, Social Interactions, and Nutrition

As the bison herd increased under Alternative 1, the number and frequency of aggressive interactions, particularly those due to competition for forage such as the displacement of elk, would likely increase.

Nutritional status would likely remain the same as under baseline conditions because supplemental feeding would continue. Currently, bison that
are fed presumably have improved nutritional status over bison on native range, although in recent years, bison on the refuge have been seen gnawing on roots and branches and eating twigs, behaviors that could indicate dietary inadequacies (Cole, pers. comm. 2004). Because bison turn to standing forage on the refuge when not actively eating at feedlines, the increase in numbers expected under Alternative 1 could result in a negligible decline in available forage and nutrition, by 0.5% in the short term and 2.5% in the long term.

Supplemental feeding would continue to contribute to the greater survival of out-of-season, late-born calves. Calves born outside the typical spring/summer birthing season would normally be highly disadvantaged from an evolutionary point of view because they would be less likely to thrive (Cook et al. 2004).

**Disease Prevalence and Transmission**

**Bovine Brucellosis**

*Prevalence in Herd* — Brucellosis seroprevalence in the Jackson bison herd would likely continue to be high (58%–84%, WGFD unpubl. data; Cain et al. 2001, 2002, 2004; Williams et al. 1993). The increased density of bison associated with this larger population could elevate prevalence of brucellosis, but the increase would be negligible to minor in the long term because seroprevalence is already high.

*Transmission among Bison* — In the short term the potential for transmission of brucellosis among bison would remain unchanged from current levels. Bison are social, gregarious animals and this behavior leads to increased opportunities for transmission of brucellosis. Increased concentration of bison on feedgrounds, rather than herd size overall, is believed to amplify transmission, as indicated by higher brucellosis seroprevalence in the 700+ Jackson bison herd compared to the 2,400+ animal herd in Yellowstone National Park (29.5%–31.8%) (Meyer and Meagher 1997; Williams et al. 1993; WGFD unpubl. data). Under Alternative 1 transmission rates could increase, but because transmission is already high, the long-term effects would be negligible.

*Transmission from Elk to Bison* — Modeling of brucellosis in the Jackson bison herd has suggested that the herd may have contracted brucellosis from the infected elk with whom they began sharing feedlines during the winter of 1979–80 (Peterson, Grant, and Davis 1991b). It is likely that transmission from elk to bison continues at some unknown rate today, and that as herd size increases, transmission would also increase. Transmission from bison to elk was covered previously in the elk impact section on disease prevalence and transmission.

**Bovine Tuberculosis and Paratuberculosis**

Bovine tuberculosis and paratuberculosis are not present in the Jackson bison herd. The risk of major adverse consequences from the introduction of either disease would be highest under Alternative 1 because of increased bison numbers combined with annual winter feeding. (See the discussion for elk under Alternative 1, “Disease Prevalence and Transmission,” for more detail.) The following impacts would occur if these diseases became established in the herd.

If bovine tuberculosis became established in bison on the refuge, it would likely be transmitted quickly (through aerosols and ingestion), would have a high prevalence in the herd (Peterson 2003), and would be self-sustainable in the population under Alternative 1. It is also probable that bovine paratuberculosis would be sustained in the Jackson bison herd.

Transmission of bovine tuberculosis and paratuberculosis from elk to bison would be very likely under Alternative 1 (HaydenWing and Olson 2003) because elk and bison would co-mingle on the refuge during winter feeding periods, elk and bison numbers and densities would be high, and bison numbers would continue to grow.

**Malignant Catarrhal Fever**

There are no reports of malignant catarrhal fever in the Jackson bison herd (Peterson 2003). The risk of introduction into either the bison or elk herd through contact with infected domestic sheep is described in greater detail in the section for elk under Alternative 1, “Disease Prevalence and Transmission.” Those alternatives that increase dispersion of animals through reductions in supplemental feeding, such as Alternatives 2 and 6, would also increase the chance of contact be-
Impacts on the Jackson Bison Herd: Impacts of the Alternatives — Alternative 1

between Jackson elk or bison and infected domestic sheep. Alternative 1 would have less risk of bison contracting or spreading the disease than those two alternatives, but a greater risk than Alternatives 3, 4, or 5, because of the ever increasing size of the bison population. More bison would increase the chance of an individual animal contracting malignant catarrhal fever.

The primary factor that would influence impacts from malignant catarrhal fever, if it became established, is animal density. Specific changes in prevalence in the herds, herd production, recruitment, mortality, and transmission are unknown for any of the alternatives. For bison, impacts would likely be greatest under Alternative 1 because numbers and density would be highest.

Calving, Age and Sex Ratios, and Recruitment

Because Alternative 1 would not include any hunting on the National Elk Refuge, and because only a small fraction of bison are harvested each year on adjoining lands, age and sex ratios of the bison herd would only be negligibly affected by hunting.

Sex ratios during 1999–2004 (excluding 2003 when there was no classification count) averaged between 80 and 90 bulls per 100 cows, and 39–45 calves per 100 cows. Hunting harvests more bulls than cows, and WGFD removals on private property tend to be bulls. In 2005–6 estimated ratios were 75 bulls per 100 cows and 45 calves per 100 cows (GTNP, unpubl. data).

Brucellosis would not impact bison production and recruitment rates more than a small amount, even in the long term. This is because female bison tend to only lose their first pregnancy following infection (Thorne, Morton, and Ray 1979; Davis et al. 1990, 1991; Cain et al. 2001), with minimal impacts to their lifetime reproductive potential. Birth fluids and material during subsequent deliveries, however, are often infectious. The Jackson bison herd is a chronically infected herd, and abortion rates in chronically infected ruminant herds are typically in the single digits (Herriges et al. 1989; Peterson, Grant, and Davis 1991a, 1991b; Smith and Robbins 1994).

Figure 3-2 (page 131) illustrates the relatively small difference brucellosis prevalence makes in overall production. Even if 100% of female bison became infected with brucellosis and produced 10 calves in their lifetime, approximately 10% of potential calf production would be lost to abortion. Therefore, any increase in prevalence expected under Alternative 1 in the long term would not increase overall bison calf losses beyond the negligible level (up to 10%).

If bovine tuberculosis or bovine paratuberculosis became established in Jackson Hole, they would affect production and recruitment mainly by lowering the number of adult females. Bovine tuberculosis or paratuberculosis could also affect age ratios because they would increase mortality, particularly in older animals.

If these diseases were introduced into the Jackson bison herd, the impacts on production and recruitment would increase over time as the number of clinical cases increased. The number of clinical cases of bovine tuberculosis would be much lower than prevalence. Subclinical infections of bovine tuberculosis do not affect fertility of female African buffalo (*Syncerus caffer*; Rodwell, Whyte, and Boyce 2001), and this is likely the case in bison. Therefore, the potential for impacts on production and recruitment would be much lower than the prevalence rates.

Mortality

Under Alternative 1 the overall annual mortality rate would continue to be relatively low and would likely remain similar to recent levels of about 6%–7%. Harvest currently causes the greatest number of known deaths, although vehicle collisions, natural causes, agency removals and other unknown causes contribute. Mortality rates determined from a radio-telemetry study monitoring a sub-sample of female bison from 1997 to 2003 allowed more precise information to be gathered and support low mortality levels (GTNP, unpubl. data). The total number of deaths (13) that occurred during the study was small, and mortality averaged 7%, including harvest (5% excluding harvest deaths; methods from Heisey and Fuller 1985). Hunters killed four, a vehicle killed one, and eight died of natural causes. Annual survival rates were high (95% and 93%, excluding and including harvest mortality, respectively).
This alternative would impose no controls on the growth of the bison herd, and as noted above, it is expected that the herd would continue its current rate of increase. Although it is possible that more bison could leave the safety of the refuge and park and be subject to hunting, it is also possible that the percentage of the herd subject to hunting would stay the same. Only negligible to minor increases in the harvest of bison are expected in the long term.

Agency removals would likely increase over baseline conditions as bison numbers continued to rise and they increasingly ventured onto private lands. Agencies removed 10 bison during 1997–2003; the percentage of the herd removed ranged from 0% (no removals in two years) to 0.7%.

The number of bison killed by vehicle collisions could increase under Alternative 1 due to a larger bison herd, if movements and distribution increased within and outside the refuge and the park. Bison deaths from vehicle collisions in recent years have been variable, and fluctuating levels would continue. During 1997–2003, vehicles killed 0.3%–1.3% of the herd each year.

Mortality due to natural causes would likely remain similar to baseline conditions. Predators would continue to have limited success at preying on bison, although calves and weak or impaired individuals would still be killed opportunistically.

If bovine tuberculosis or paratuberculosis was introduced to the herd, adult bison mortality would increase as the number of clinical cases of these diseases increased. Because bison numbers and densities would be higher under Alternative 1 than any other alternative, mortality would be highest under this alternative.

**Health, Sustainability, and Naturalness**

The Jackson bison herd might maintain relatively good health and continue to be self-sustaining if a serious non-endemic disease other than brucellosis did not infect it. However, high ungulate concentrations during nearly annual winter feeding would increase the risk of disease transmission and adverse impacts if the herd became infected. Concentrating large numbers of bison on feedlines for several months nearly every year would increase the chances of contact with infected adults or aborted fetuses of bison and elk infected with brucellosis, as well as increase the probability of quickly spreading any new disease. Risk would be particularly high under Alternative 1 because of the combination of high numbers of bison and elk and the high frequency of supplemental feeding.

Barring the introduction of a serious non-endemic disease, the herd would continue to be genetically viable. Limited harvest and lower-than-natural winter mortality would continue to allow nearly all bison in the herd to survive and reproduce, and the herd would expand from approximately 1,000 bison at the time of the Record of Decision is signed.

Under this alternative management would continue to affect the naturalness of population parameters and processes in the bison herd. The size of the bison herd would be larger than the number of bison that inhabited the valley prior to Euro-American settlement, especially in winter. Rather than many groups of bison roaming in search of available forage, as occurred naturally, the herd would continue to be concentrated in a relatively small area for several months each winter.

The sex ratio would likely not be substantially different than natural conditions because hunting at this low level has only a minimal influence on the sex ratio. The age ratio would continue to be altered by the winter feeding program, as calves would have a higher chance of survival when born in the winter than in natural populations.

Because of its effects on mortality rate, distribution and movement, production and recruitment of calves, Alternative 1 would result in the lowest level of naturalness in the bison herd, even though some aspects of naturalness (e.g., sex ratio, fewer hunter-killed bison) would be higher than under some alternatives.

**Conclusion**

Under all alternatives there would be an estimated 1,000 bison in the Jackson herd at the signing of the Record of Decision. Based on the previous five-year growth rate, under Alternative 1 the number of bison could grow to as many as 2,000 by 2014. Larger numbers of bison on the refuge would also likely result in increased competition for forage and displacement of elk, as well as in-
creased movements and distribution, possibly making greater use of the national forest and private lands in Jackson Hole and Buffalo Valley. Nutritional status would remain high (due to supplemental feeding in the winter), and production, recruitment, and annual survival would also remain high. The sex ratio would likely remain near 1 to 1, and calf production and recruitment would remain high as compared to a non-fed population.

The risk of a non-endemic infectious disease quickly spreading through the bison population would be the highest of any alternative due primarily to the near-annual winter feeding program and the growing number of bison. Therefore, this alternative would have the greatest risk of a non-endemic infectious disease having a major adverse impact to survival, population size, and sustainability. The prevalence of brucellosis in the bison herd would remain high (58%–84%) and could increase somewhat due to higher bison numbers and greater chances for transmission. Of all alternatives, Alternative 1 would result in the lowest level of long-term health, sustainability, and naturalness in the bison herd.

Barring the establishment of a fatal, infectious disease, no impairment to the bison herd is expected. If such a disease did become established, this alternative would have the highest chance of substantially reducing or perhaps even impairing the park herd.

**ALTERNATIVE 2**

**Analysis**

**Bison Numbers**

Under Alternative 2 the number of bison would decrease, perhaps substantially, over time as supplemental feeding was phased out. No objective for herd size would be set under Alternative 2. A herd size of 250–500 was chosen for the purposes of this analysis, although under minimal management population highs might exceed 500 bison and population lows might be lower than 250.

Despite this alternative’s emphasis on minimal management, fertility control would be used during the short term to lower calf production and reduce herd growth, thus limiting increases in mortality as the feeding program was phased out (see text box and Appendix B for a more detailed discussion). Changes in the population would be closely monitored, and adaptive management would identify exactly when fertility control would be discontinued and points at which the feeding program would be phased back. Additional NEPA analysis could be needed prior to fertility control implementation if information on the state-of-the-art changed significantly.

Converting cultivated fields on the refuge to native vegetation and discontinuing irrigation would provide less forage and could contribute to lower bison numbers. Some bison would leave the area in search of additional native winter range and enter Bridger-Teton National Forest, where hunting is allowed. Therefore, deaths from hunting would be possible.

Herd size would decrease primarily during severe winters, and perhaps during above-average winters, although enhancements in winter habitat in areas of Buffalo Valley and the Gros Ventre River drainage could provide additional forage in lieu of supplemental feeding. Agency removals and perhaps harvest would increase to some extent outside the refuge and the park. In the long term bison numbers would fluctuate more naturally, based on weather conditions and predation, and more widely than under baseline conditions and compared to Alternative 1. Bison numbers could increase after fertility control was discontinued (after 15 years).

**Distribution and Movements of Bison**

Distribution would not differ initially from baseline conditions and Alternative 1 because supplemental feeding and cultivation of forage would continue to attract bison to the refuge. As the number of non-feeding years increased and cultivation stopped, bison would increasingly disperse to find native forage. The effects of short-term fertility control on bison movements and distribution would vary depending on which contraceptive method was chosen, and the timing, as previously discussed. Disturbance during winter could cause some dispersal and a wider distribution. More likely, displaced bison would move a short distance and return to the feeding area, either after a short calming period or after the fertility control operation ended for the day. There would be no known effects on movements and distribution be-
Fertility Control in Bison

Fertility control in bison could be achieved through surgical sterilization, which would be permanent, or biochemical contraception, which usually lasts for one breeding season. (Chemical sterilization caused by injecting a caustic chemical into gonads and rendering animals permanently infertile is not considered.) It is estimated that 1,000+ bison would be wintering on the refuge at the time the Record of Decision was signed, and 36% (288–360) would be adult females.

Permanent sterilization of female bison would involve immobilization and performing an ovariectomy, which if performed in the first trimester of an animal’s pregnancy would cause abortion. Consequently, they should not be performed any sooner than February or early March to avoid pregnant bison that are in their first or early in their second trimester (Roffe, pers. comm. 2004). Late-breeding females that were still in their first trimester of pregnancy would abort their fetuses after removal of the ovaries even when sterilizations were performed after February or March. Since Jackson bison have high levels of brucellosis, this could increase transmission among elk and bison. If these operations were conducted on the refuge feedlines, a maximum of 8 operations per day could be performed or up to an estimated 440 operations per season (assuming a 55-day season).

In Grand Teton National Park bison tend to congregate on the east side of the park. If animals were not next to a road, teams would have to hike within darting range (35–75 yards). Animals that have never been darted before would be easier to approach than animals that have been previously captured. Bison are potentially dangerous when stalked too closely, and extra care must be taken when working on an animal while surrounded by other bison. For the purpose of this analysis, 5 bison per day could be surgically sterilized, or up to an estimated maximum of 420 bison per season (assuming an 84-day season; Roffe, pers. comm. 2004).

Using biochemical contraception, such as porcine zona pellucida (PZP), gonadatropin releasing hormone (GnRH or GnRH vaccine), or leuprolide, on the refuge feedlines would make it easier to find and dart animals, compared to other seasons when they are free-ranging. Each animal would have to be handled, either to tag it with a “Do Not Consume” tag (if PZP or GnRH was used because neither of these chemicals has been approved by the Food and Drug Administration for human consumption) or to hand inject the contraceptive (if GnRH vaccine or leuprolide was used). A maximum of about 16 bison per day could be treated if each animal had to be handled (Roffe, pers. comm. 2004). The risk of causing abortions on the feedlines and the potential for increasing transmission of brucellosis would be an important consideration because many bison would be pregnant during the feeding period. PZP is the only biochemical contraceptive that has been shown to be safe during all stages of pregnancy (Miller, pers. comm. 2004; Kirkpatrick, pers. comm. 2002). Leuprolide must be administered in August for the drug implant to be effective. GnRH is safe in the later stages of pregnancy but could not be used early in the winter feeding season (Rhyans, pers. comm. 2003).

If biochemical contraception was administered in Grand Teton National Park, 8 bison per day could be treated (Roffe, pers. comm. 2004). If delivery occurred in July, August, September, and October, PZP and GnRH would likely not cause abortions in bison while cattle are grazing in the park. However, if leuprolide was used, late-breeding females could abort, increasing the potential for transmission of brucellosis to cattle.

Unlike treatment with GnRH or leuprolide, which require a single injection, animals receiving PZP treatment for the first time would need a booster shot after about 30 days. In addition, ungulates contracepted with PZP have experienced repeated estrous cycling beyond the normal breeding season (Heilmann et al. 1998; L. A. Miller, Johns, and Killian 2000b). Biologists would need to determine if this is an acceptable behavioral side effect.

The quickest way to bring down numbers would be to prevent pregnancy in all adult females for at least the first few years. This would have the added benefit of potentially reducing the spread of brucellosis among bison or to cattle grazing in the park. However, permanent surgical sterilization of all females would mean that the herd would eventually become extinct, so biologists would have to determine the exact percentage that could be surgically sterilized and still maintain genetic viability. In the absence of hunting on the refuge, it would take longer than 10 years to reduce the herd to 450–500 animals if fewer than 100% of the female bison were surgically sterilized or biochemically contracepted. If biochemical contraception was used, after reducing the herd to approximately 450–500 animals, treatment could be stopped and natural forces could be allowed to regulate bison numbers in the future. Changes in the population would be closely monitored, and adaptive management would identify when fertility control would be discontinued and points at which the feeding program would be phased back.
beyond their normal distribution on the east side of the park.

Some bison would likely travel south and onto private lands in and near the town of Jackson. Hunting on the northern end of the refuge would encourage movement south as well. Removals of individual animals on private land by WGFD personnel could increase as a result.

Based strictly on environmental conditions, results of a forage availability model (Hobbs et al. 2003) indicated that ungulates could winter best in the Gros Ventre River drainage and south of the town of Jackson in the Snake River Valley, particularly near Alpine and including lower portions of Hoback Canyon. Forage enhancements east of the refuge and the park could also attract ungulates. But private lands interspersed with national forest and elk feedgrounds in all these areas would impede bison colonization, and free-ranging bison would likely not be allowed. They would be hunted or removed by the state because of threats to public safety, property, or the health of domestic livestock (WGFC regulations, ch. 41 (2002) and 15 (2004)).

Negligible changes to distribution would occur due to the elimination of prescribed fire and the nutritious grasses that it creates on the refuge. No changes to the prescribed fire program in the park would be made under this alternative.

In addition, if attempts to acquire conservation easements and private land on the refuge were successful, these procurements would prevent further loss of habitat to development, providing bison with continuing sources of good habitat and promoting wider distribution.

As noted above, no bison herd size objective is built into this alternative, and the herd could be smaller than 250 or larger than 500. If it was on the small end of this range, distribution in the long term could remain similar to what it is now, and the entire herd could overwinter on the refuge and subsist on native forage. If the herd was larger, it is likely that numbers would still fall below current baseline conditions and would undoubtedly be smaller than under the long term under Alternative 1.

Areas of summer distribution would be expected to remain similar to areas currently used under baseline conditions because of the inclination bison have for traditional areas.

**Bison Behavior, Social Interactions, and Nutrition**

The effects of short-term fertility control on behavior and social interactions would vary depending on the timing of delivery, delivery method, and type of contraceptive, as previously discussed. If bison were darted and immobilized during winters when supplemental feeding on the refuge was taking place, they could be displaced from feedlines, and some animals could leave one feeding group and join another. Some bison could become agitated, expend energy running, or be involved in social interactions more frequently than usual. If bison responded in this way, the amount of time spent feeding would decrease and injuries, including goring, could increase. These short-duration, negligible to minor behavioral effects would be relatively uncommon if fertility control only occurred during feeding years. The presence of active feedgrounds would increase the likelihood that bison would remain nearby and would not move more than a short distance from the feeding area.

If bison were immobilized in the park during other seasons, behavioral effects would be of short duration and negligible to minor, similar to those described above. Temporary habitat loss would occur due to short-term disturbance. If some bison became agitated and ran from their group, they could run farther than they would on winter feedgrounds. During the rut the possibility of injuries and greater energetic expenditures would likely be similar to what would occur at winter feedgrounds, but some effects could increase. Rutting bulls in large breeding groups might interfere with immobilization activities or run after females that have been darted with immobilization drugs but had not yet become immobile.

Ballistic delivery, whether on the refuge during winter or in the park during other seasons, would also cause short-duration, negligible to minor behavioral effects, but not to the same extent as immobilization. Darts would strike individual bison, but no other handling would be required. Numbers of personnel for a limited time would be similar to those required for immobilization.
The various fertility control methods would affect bison behavior differently and for varying lengths of time. For example, surgical sterilization would alter breeding behavior in treated cows permanently, and reversible contraceptives would influence behavior for shorter time periods.

Permanently sterilized cow bison would not experience estrous cycles, but would behave normally otherwise. Rhyan and Drew (2002) state that in most herds there probably are individual animals that do not experience estrus because of health-related conditions, which would be similar to sterilized cows. Social interactions and energetic expenditures would decrease because bulls would ignore these anestrous cows during the breeding period, and the nutritional status of treated cows would be improved. Treated cows would be able to forage undisturbed by bulls during the breeding season. These effects would begin during the short term under Alternative 2 and would continue for the life of treated bison, unlike short-term, reversible contraceptives. Behavioral and nutritional effects during the breeding season would be similar in bison repeatedly treated with a contraceptive that inhibits estrus. Behavioral and nutritional effects during the breeding season would be similar in bison repeatedly treated with a contraceptive that inhibits estrus. Bison repeatedly treated would experience the short-duration effects associated with immobilization or ballistic delivery multiple times compared to surgically sterilized bison that would require one procedure.

The use of PZP vaccines would increase disturbance and alter behavior in several ways. Most formulations require one or more booster vaccinations to provide sterility for more than one year, and repeated deliveries would increase short-term disturbance. In addition, PZP vaccines in some species cause recycling (estrous cycles that continue to occur beyond the normal breeding period). If treated bison cows experienced repeated estrous cycles during the breeding period because they continued cycling but were infertile, the nutritional status of bison would be decreased for both treated cows and bulls. Treated cows would experience increased caloric expenditure and decreased feeding during early winter, as would bulls that continue to form breeding associations and exhibit rutting behavior in response to the presence of receptive cows. Declines in physical condition could affect winter survival of dominant bulls and treated cows. Although both bulls and treated cows in food-stressed populations could experience greater stress if the breeding period is prolonged, not becoming pregnant and not lactating could compensate females for increased stress (McShea et al. 1997).

GnRH vaccines, in contrast, do not cause repeated estrous cycles, and they contain a diluted, approved cattle vaccine as an adjuvant to boost immune response rather than Freund’s Complete Adjuvant (FCA; a non-FDA approved adjuvant used with PZP). In recent studies, GnRH has produced sterility for one to two years with a single injection in female white-tailed deer (L. A. Miller et al. 1997), and preliminary results in bison are promising (Rhyan and Drew 2002). Treated females would require boosting each fall or every other fall to maintain high titers and infertility. The lack of estrous cycling and breeding behavior in treated cows would decrease social interactions and energetic expenditures, and would improve nutritional status, similar to sterilization effects.

GnRH agonists contain synthetic compounds to make them more potent than GnRH alone. Leuprolide has been effective for one breeding season in captive elk (Baker et al. 2002). Delivery in this case was through subdermal implants, which would require immobilization. During trials in elk, rates of reproductive behavior were similar for treated and untreated females although the daily rate of sexual behavior decreased over time for untreated females. Sexual interest towards treated females was extended early in the breeding season compared to pregnant, untreated females but recurrent estrous cycles and ovulation did not occur. If bison cows were treated with leuprolide, these extended interactions would increase energetic demands and nutritional status in treated females and breeding males to a limited extent.

The gradual reduction of years of supplemental feeding on the refuge under Alternative 2 would confine feedline behavior and competitive social interactions associated with feedlines to feeding years (see Alternative 1 for more detail). Interactions common on feedlines would be much less prevalent during non-feeding years.

Overall, bison nutrition could begin to decline in the short term as numbers remained high and feeding stopped. As supplemental feeding was reduced to fewer winters, cultivated fields would be converted to native vegetation, and bison
would have to rely on native vegetation. During severe winters nutritional status could be decreased, and moderate to major increases in mortality could occur compared to existing (unnatural) conditions. As bison dispersed, were hunted, or died of malnutrition and the herd decreased in size, nutrition levels would likely rebound.

Eventually, nutritional status of bison under Alternative 2 would mimic free-ranging, non-fed bison populations. Bison would be expected to exhibit behavioral and metabolic changes to survive winter stresses similar to those exhibited by deer and elk. Reduced activity levels and metabolic rates, as well as insulated winter coats, behavioral adaptations, and catabolism of body fat allow white-tailed deer to cope with the energetic costs of winter (Mautz 1978). Although some bison could die during above-average and severe winters because of decreased nutrition and body condition, at low numbers most should be able to maintain adequate nutritional levels on native forage. Although decreases in cultivation and loss of herbaceous forage on the refuge would contribute to lower nutritional levels, this could be partially mitigated by the greater long-term palatability of some native species (Brock, pers. comm. 2003) and habitat enhancements outside the refuge and park. Fall range on the refuge and in the park would also be more available to elk due to the elimination of hunting or elk reduction in those areas. If as a result elk foraged longer in the park and moved onto the refuge later, there could be more forage on the refuge for winter use by both bison and elk. Because fewer bison would be more widely dispersed, the use by bison of woody vegetation on the refuge would decrease in the long term.

Competition with elk for forage in transitional habitat would continue, but would decrease under Alternative 2. Displacement of elk would occur more rarely because of fewer bison and elk, and wider ungulate distribution on native range. This would also be true in winter habitat in below-average to average winters. During shortages of native forage in above-average winters, aggressive social interactions involving competition for food with other bison and with elk could increase.

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**Effects of Brucellosis on Herd Production**

Brucellosis currently results in less than 10% loss of calves in the Jackson bison herd. Reduction in prevalence would also reduce the loss of calves, but since it would only affect the first birth of most females, overall effects on herd productivity would be negligible. If the percentage of female bison infected with brucellosis in their lifetime was reduced to 30% and the females produced 10 calves in their lifetimes, on average, the overall loss in calf production due to brucellosis would only be approximately 3.0% (see Figure 3-2).

**Disease Prevalence and Transmission**

**Bovine Brucellosis**

Prevalence in Herd — It has been shown that the proportion of a bison population infected with brucellosis increases as a relatively simple function of population density when the animals are not supplementally fed (Dobson and Meagher 1996), even in a population as small as 200 animals. Given 250 as a lower end estimate for this herd after feeding stopped, it is likely that brucellosis would still be maintained in the Jackson bison herd, although at reduced prevalence. Decreased animal density and elimination of supplemental feeding would result in a moderate, long-term decrease in brucellosis prevalence in the Jackson bison herd compared to Alternative 1.

Transmission among Bison — The lower density and lower prevalence of brucellosis would result in fewer abortions and less chance of contact with abortions that do occur. Although this would mean a major reduction in transmission of bison on the refuge, transmission would likely remain higher than levels in Yellowstone National Park due to initially higher seroprevalence (Meyer and Meagher 1997).

Transmission from Elk to Bison — Although rates of transmission from elk to bison would not change in the short term, a major decline in transmission rates from elk to bison would eventually occur as populations declined and prevalence in elk dramatically decreased. In the absence of winter feeding, interspecies transmission between elk and bison would be low (Ferrari and Garrott 2002).
Bovine Tuberculosis and Paratuberculosis

Neither of these diseases is present in the bison herd. Both the risk of either spreading in the herd and the prevalence in the herd should it become infected are much lower than under Alternative 1. This is also true of the risk of spread from elk to bison. Overall Alternative 2 would have a relative major benefit in reducing risk, prevalence, and transmission of both bovine tuberculosis and paratuberculosis compared to Alternative 1. The reasons for these decreases in risk and in potential prevalence are the phasing out of the supplemental feeding program and associated densities, and the reduced number of both bison and elk. See the discussion for elk under Alternative 1 for “Disease Prevalence and Transmission” for more details.

Malignant Catarrhal Fever

The risk of bison contracting malignant catarrhal fever would be greatest under Alternative 2 (along with Alternative 3, and Alternative 6 to a lesser degree) because of possible migration out of Jackson Hole to other wintering areas. For greater detail, see the elk section under “Disease Prevalence and Transmission” for Alternative 1.

If malignant catarrhal fever became established, the relatively low levels of bison and elk density would likely keep the spread minimized, and the potential for impacts would be lowest under Alternative 2 (along with Alternative 6) compared to the other alternatives.

Calving, Age and Sex Ratios, and Recruitment

Hunting on Bridger-Teton National Forest could affect herd composition. In order to maintain an approximately equal sex ratio, which would be typical of unmanaged herds, harvesting would need to remove approximately equal numbers of both sexes. In the short term more females would be targeted (Brimeyer, pers. comm. 2004). Gradual increases in calf winter mortality and the use of fertility control during the short term would lower the proportion of calves in the herd compared to baseline conditions and Alternative 1. Although more older bison would also succumb to winter mortality, calves would likely be the most vulnerable. Ratios would reflect fewer calves and a greater proportion of bison older than 1 year. Decreases in the number of calves would depend on success in delivering the contraceptive and on the length of the fertility control period in the case of short-term contraceptives. The male-to-female ratio would likely remain similar to baseline conditions and Alternative 1.

Various forms of fertility control would also alter breeding ratios. If some females were permanently sterilized, they would not experience estrus and would be unavailable for breeding. Bulls would ignore them during the breeding period. With some forms of short-term contraception, treated females would experience estrous cycles and engage in breeding activities but would not become pregnant. They would attract the interest of males for longer periods of time than would untreated cows that might become pregnant early in the breeding season.

More bison could be removed annually by WGFD personnel due to impacts on private property, compared to Alternative 1, because the refuge feedground would no longer restrict the winter distribution of most of the bison herd. Although increases in agency removals could taper as the herd became smaller, the percentage affected in the population could remain static.

Mortality rates would increase, especially in older bison and calves. Calf production and recruitment would both likely be lower in the long term compared to Alternative 1, as bison calves would experience greater mortality and a higher number of adult females would be in poorer condition and would not bear calves. Reductions in brucellosis and abortions would result in a minor to moderate decrease in calf losses in the long term, but this would constitute only a negligible positive contribution to calf production in the herd in the long term.

If bovine tuberculosis or paratuberculosis infected the population, production and recruitment could be reduced if reproductive age bison died, as well
Impacts on the Jackson Bison Herd: Impacts of the Alternatives — Alternative 2

as calves themselves. Bovine tuberculosis and paratuberculosis could also affect age ratios because they tend to kill older animals. Because densities, and hence prevalence, would be significantly lower under Alternative 1, the potential number of clinical cases and the overall effect on mortality rates and production losses would be lower. A major difference in production losses would be possible, although the effect on production in the herd would be low.

Mortality

Bison mortality unrelated to harvest would gradually increase under Alternative 2 as supplemental feeding and cultivation of standing forage were reduced and bison relied more on natural forage. Because winter feeding would first be eliminated in mild winters and then progressively severe winters, initially there would be little change from baseline mortality levels. Bison would gradually be more affected by natural processes, and mortality would reflect winter severity, ranging from low during mild winters to high during severe winters. Habitat enhancement outside the refuge could decrease winter mortality to some extent by providing additional forage.

The WGFD hunt program would be unchanged from the program under baseline conditions and Alternative 1. Harvest would continue in Bridger-Teton National Forest east of the refuge and the park, its success dependent on fall bison distribution and the number of bison that leave safe areas. Because high numbers of bison would exist initially and distribution could increase as bison increasingly depend on native vegetation in more years, harvest could increase in the short term. However, if the bison herd became smaller during the short term and/or fall distribution did not increase substantially, annual harvest in the national forest would likely remain low, similar to harvest levels under baseline conditions. These bison movements could also increase the number of bison deaths from vehicle collisions.

Predation on bison would likely increase negligibly. Although the species is large-bodied, able to defend young, and less vulnerable than other prey, predators would kill more bison under Alternative 2 because total dependence on natural forage in above-average and severe winters would lower physical condition in some animals, making them easier prey. This increase would likely be compensatory because some vulnerable bison would otherwise succumb to winter mortality. Calves, cows, and older bison would continue to be the most vulnerable to predation.

The increase in mortality from reduced body condition would be lowered somewhat by a reduction in prevalence of brucellosis and the potential for new infectious disease to spread. As noted above, potential mortality from bovine tuberculosis or bovine paratuberculosis would be lower under Alternative 2 by a moderate to major amount compared to Alternative 1 because prevalence, and thus number of clinical cases, would be lower by a major amount.

Health, Sustainability, and Naturalness

The health and sustainability of the Jackson bison herd would increase gradually as supplemental feeding was progressively reduced to fewer years and there was greater reliance on natural forage. Lower bison numbers and concentrations in the short term would result in lower disease prevalence and transmission of current diseases such as brucellosis, as well as of any non-endemic infectious disease. Alternative 2 would lower the risk of future population declines or depopulation events from bovine tuberculosis, for example, or other non-endemic disease. Effects of hunting on health and sustainability would continue to be negligible, and they might be reduced in the long term if herd size decreased significantly. Fertility control would diminish naturalness temporarily in terms of population processes, but its use would be short term. Fertility control would be discontinued once the size of the population better matched the available forage, which would enhance naturalness in terms of both population size and habitat conditions, or when the bison herd size approached 400, whichever occurred first. Health and sustainability under Alternative 2 would be greater than what would occur under all other alternatives, except Alternative 6.

Barring the introduction of a serious non-endemic disease or very high mortality, the herd would continue to be genetically viable. If severe weather conditions occurred in consecutive years, high mortality, resulting in a small herd size, could threaten genetic viability. A herd of 500 bison or more would be genetically viable and "self-
sustaining.” But without human intervention, genetic viability could be threatened if the herd dropped below 400 animals and effective population size decreased below 100 (Berger 1996). If the herd fell below 400, the periodic introduction of females from genetically unrelated herds would be required. This occurred when nine bison moved from Yellowstone National Park to Jackson Hole in 1996–97, but similar movements might not recur. Herds without cattle genes and with high genetic variability would be candidates for donors to the Jackson herd should the need arise for managers to accomplish introductions.

The bison herd would be more natural because it would rely on native forage and be more subject to environmental factors. Bison numbers, recruitment rates, and age and sex ratios would also be more natural without supplemental feeding. As in unfed populations, climate and the abundance of native forage would have a much greater influence on movements and distribution. As the size of the herd decreased, bison numbers would be closer to the low number of bison that probably inhabited the valley prior to Euro-American settlement. Fewer human-related deaths (such as traffic collisions) would occur once bison numbers reached a lower level.

Bison behavior would also become more natural. Competitive social interactions and displacement of elk and other bison from feedlines would decrease as densities declined.

Of all alternatives, Alternative 2 (and Alternative 6) would result in the highest level of naturalness in the bison herd, although some aspects of naturalness (e.g., short-term use of fertility control, potential introductions to address genetic concerns, and resultant changes in calf production and age ratios) would temporarily be lower under Alternative 2 than under other alternatives.

Conclusion
In the long term under Alternative 2 there would be an estimated 250–500 bison in the Jackson herd, which would be lower than Alternatives 1 and 3, and similar to or below Alternatives 4, 5 and 6. After supplemental feeding and forage production on the refuge were phased out, and after fertility control ended, bison would disperse onto native range and become more subject to climate, predation, and the abundance of forage. Nutritional status would fluctuate with winter severity, precipitation, and available forage, and mortality would increase during more severe winters. Although annual survival, recruitment, and sex and age ratios would be more natural and reflective of non-fed populations, they would vary from Alternative 1. Recruitment and annual survival would decrease compared to Alternative 1. Although genetic viability could be threatened if the bison herd decreased below 400 animals, periodic introduction of unrelated bison would be used to counter this threat to herd health.

The risk of a non-endemic infectious disease quickly spreading through the herd, and associated major adverse impacts, would be the lowest (along with Alternative 6) of any alternative. The prevalence of brucellosis in the bison herd would be moderately lower than under Alternative 1. Contraception in the short term under Alternative 2 would cause temporary impacts on population numbers and ratios. During years fertility control was undertaken, the proportion of calves in the Jackson bison herd would be reduced, and older animals would constitute most of the herd. If surgical sterilization was performed, effects would continue for the lifespans of treated animals, possibly for several years into the long term. The effects of reversible contraceptives would be temporary, and age distributions would return to pre-contraception levels after several years.

Alternative 2 (along with Alternative 6) would result in higher levels of long-term health, sustainability, and naturalness in the bison herd than what would occur under Alternatives 1, 3, 4, and 5.

No impairment to park bison would occur under Alternative 2. If the park population dropped below that needed to sustain genetic viability, bison from other areas would be screened and imported to increase the size and genetic variability of the herd.

**ALTERNATIVE 3**

**Analysis**
This alternative would actively manage elk and bison to keep numbers at designated levels (1,000–2,000 elk, about 1,000 bison) by minimizing
Impacts on the Jackson Bison Herd: Impacts of the Alternatives — Alternative 3

supplemental feeding, using habitat improvement, and changing hunting regimes to encourage elk and bison to disperse. Feeding would be reduced over time so that by year 10–15 supplemental feeding would be provided only in the most severe winters. Vaccination for brucellosis would occur if a safe vaccine with more than 50% effectiveness was developed.

Bison Numbers

The bison population objective under Alternative 3 would be the number in the herd at the signing of the Record of Decision. This number is expected to be larger than 1,000 if herd growth continues at 10%–14% (including losses from hunt mortality). Initiating bison hunting on the refuge would sustain bison numbers at the objective. The herd would be smaller than under Alternative 1 but larger than under the other alternatives.

Distribution and Movements of Bison

As in Alternative 2, winter feeding would be decreased over a 15-year period, and distribution during feeding years would remain similar to baseline conditions. As reliance on standing forage in non-feeding years increased and feeding occurred in an estimated 2 of 10 winters on average, bison movements and distribution would similarly increase.

Irrigation and cultivation of standing forage on the refuge could continue as it is now under Option A of this alternative, or cultivation could be phased out and converted to native range under Option B. Under Option A bison movements to the refuge during the winter would continue, although at lower numbers than under Alternative 1. Fewer bison might move onto the refuge under Option B without the attraction of cultivated fields. Under either option bison would also range to areas outside the refuge where habitat enhancements would occur, including Buffalo Valley and forest lands east of the park. The Gros Ventre River drainage could also draw bison. Prescribed fires on the refuge, as well as in the park, would continue to enhance forage and habitat, attracting bison to treated areas, as under baseline conditions and Alternative 1. If attempts to acquire conservation easements were successful, these procurements would prevent further loss of habitat to development, providing bison with continuing sources of good habitat and promoting wider distribution.

As in Alternative 2, bison might also use areas along the Refuge Road and wander into the town of Jackson, resulting in the increased potential for WGFD removals of bison from private land.

Alternative 3 includes the initiation of a bison hunt on the refuge. This change could temporarily alter distribution in the fall as bison moved away from the hunt areas to safe, non-hunt areas on the refuge, in the park, or in Bridger-Teton National Forest during the hunting season. Bison could increase use of the southern part of the park (Antelope Flats, the Kelly hayfields, and Blacktail Butte) during this period and the northern portion of the refuge because these areas would be closed to hunting under this alternative.

If safe brucellosis vaccines were developed with a minimum efficacy of 50% for both bison and elk, vaccine delivery would take place during winter supplemental feeding on the refuge. Individual animals would need to be immobilized unless biobullet use on bison became viable by the time an appropriate vaccine was available. Darting and immobilization or delivery of a biobullet using airguns on refuge feedgrounds would likely cause bison to move a short distance and return to the feeding area, either after a short calming period or after vaccination activities ended for the day. Delivery of an effective oral vaccine in food during non-feeding years, if such a vaccine was developed, could temporarily change distribution.

Bison Behavior, Social Interactions, and Nutrition

Changes in feeding and forage, hunting, and to a lesser degree vaccination (if it occurred) could influence behavior, social interactions, and nutrition.

Competition for food on the refuge would shift from that during supplemental feeding seen now, to competition for available cultivated and native forage. Competition for standing forage would be particularly high during non-feeding years in the short term, before bison and elk numbers declined. Over time bison social interactions and displacements of elk and other bison would decrease due to lower elk numbers and densities and
wider ungulate distribution on native range. During years with supplemental feeding (estimated as 2 years of 10), social interactions would be similar to baseline conditions. After the morning feeding period, when bison and elk would disperse short distances to feed on nearby vegetation, more interactions and displacements would occur in localized areas than would occur in non-feeding years.

Bison hunting on the refuge could also temporarily affect bison behavior and nutrition, as bison would be agitated and nervous and would expend additional energy avoiding hunters.

Bison could also temporarily experience increased nervousness and excitability or increased energetic expenditures from running or aggressive social interactions due to short-term vaccination activities.

Delivery of an effective oral vaccine in food during non-feeding years, if such a vaccine was developed, could temporarily change distribution and behavior as compared to a normal non-feeding situation. Changes in bison distribution and densities at vaccine delivery sites might cause short-duration, localized increases in aggressive social interactions. If an oral vaccine was delivered during winter supplemental feeding, distribution and movements would remain similar to baseline conditions and Alternative 1. Additional analysis under the National Environmental Policy Act might be needed prior to implementation of oral vaccine delivery.

The nutritional status of bison would be lower in some years as supplemental feeding was reduced, although not as much as under Alternative 2 because feeding would continue in severe winters. Bison would be managed so that numbers would approximate existing baseline levels, but the number of elk would be dramatically reduced. In addition, irrigation and cultivation on the refuge could continue (Option A) and habitat outside the park in Bridger-Teton National Forest would be improved. The northern portion of the refuge would be closed to elk hunting, which would further disperse elk away from lands grazed by bison on the refuge. Bison would be more likely to stay longer in these transition areas, which would preserve larger amounts of forage on the refuge for winter use. During milder years, some bison would likely winter there if forage remained accessible.

Total amounts of herbaceous forage under Option B would be similar to those described under impacts of Alternative 2 (an estimated 12% less than under baseline conditions and an estimated 10% lower than under Alternative 1 in the long term). Although herbaceous forage would be reduced, conversion to native species (particularly bunch grasses, which hold nutrients in plant parts longer than some cultivated species) would at least partially offset reduced productivity (Brock, pers. comm. 2003). During winters with above-average snow, to the extent that snow depths made forage inaccessible to bison, nutrition and body condition could decrease.

The use of woody vegetation by bison would decline under Alternative 3 compared to Alternative 1 and baseline conditions, although not as much as under Alternatives 2 and 6. The high concentrations of bison that have been attracted to and maintained near feedgrounds would be reduced since supplemental feeding on the refuge would occur in fewer years. Use would increase during some above-average winters when forage was more difficult to access because of snow, partially offsetting decreased use due to wider distribution.

**Disease Prevalence and Transmission**

**Bovine Brucellosis**

*Prevalence in Herd* — Reduced animal densities on the refuge due to fewer feeding years and habitat enhancements outside the refuge and park would have minor to moderate beneficial impacts on brucellosis seroprevalence, even in the absence of vaccination.

Modeling efforts by Gross, Miller, and Kreeger (1998) and Dobson and Meagher (1996) suggested that approximately 50%–60% of bison in a population would have to be successfully vaccinated in order to eliminate brucellosis in the long term. If a vaccine was only 50% effective, modeling of the Jackson bison herd by Peterson, Grant, and Davis (1991b) indicated that delivery to 95% of bison calves would lower seroprevalence by approximately 50% over 20 years, a moderate decrease. Vaccine efficacy of 50% or greater was designated as the desired level because this level might be
Impacts on the Jackson Bison Herd: Impacts of the Alternatives — Alternative 3

Attainable and could have some significant impact on prevalence. Biobullet or oral delivery would be required to achieve this kind of vaccination success.

Transmission among Bison — Bison maintain brucellosis at relatively high rates under free-ranging, non-fed conditions (Dobson and Meagher 1996). Transmission rates under this alternative would be lower than under Alternative 1 due to wider dispersal in most years and a reduced prevalence rate. During the most severe winters, when feeding would occur, potential for transmission would be higher than in non-feeding years. Overall, the transmission rate among bison without vaccination would be reduced by a negligible to minor amount under Alternative 3 in the long term. With vaccination, transmission rates might be reduced by a moderate amount.

Transmission from Elk to Bison — In the absence of winter feeding, transmission between elk and bison is low (Ferrari and Garrott 2002) because behavioral differences normally keep the two species separate. As a result, the risk of potential transmission from elk to bison would result in moderate to major reductions under this alternative.

Bovine Tuberculosis and Paratuberculosis

Bovine tuberculosis and paratuberculosis are not present in the Jackson bison herd. The relative risk among the alternatives that either of these diseases would become established would be low under Alternative 3 because of the reduction of winter feeding to severe winters only. If either disease infected the bison herd, prevalence would be moderately lower under Alternative 3 compared to Alternative 1 because of fewer animals and reduced winter feeding. Transmission rate would also be lower by a minor to moderate amount than if either disease infected the herd under Alternative 1. Transmission potential from elk to bison would be lower by a moderate to major amount because of these same factors and significantly fewer elk on the refuge.

Malignant Catarrhal Fever

The risk of introducing malignant catarrhal fever would be higher under this alternative than most others (except Alternative 2) because dispersion would be encouraged, but the risk of the disease spreading or having major adverse impacts would be lower than under Alternative 1 and similar to Alternatives 4 and 5 because of similar winter feeding scenarios and bison/elk densities.

The panel of wildlife disease experts did not believe enough information existed to determine the more subtle differences in impacts of malignant catarrhal fever under Alternatives 3, 4, and 5 (Disease Expert Meeting 2002). Although more bison would exist under Alternative 3 than under Alternatives 4 and 5, feeding under Alternative 3 would occur in roughly 2 out of 10 years. Alternatives 4 and 5 would have fewer bison but also would have more winter feeding, which would maintain higher densities and stresses while bison were being fed. Overall, the potential for impacts under Alternative 3 would be similar to Alternatives 4 and 5, but greater than under Alternatives 2 and 6, and less than under Alternative 1.

Calving, Age and Sex Ratios, and Recruitment

Although hunting has the potential to affect sex and age ratios, WGFD personnel would issue hunting licenses in proportions that would maintain a bull-to-cow ratio of 1 to 1 and natural age ratios. By doing so, effective population size and genetic variability would be maximized.

Continuing to feed bison in severe winters would result in a higher survival rate in calves than in unfed populations, although calf mortality would increase beyond what it is under baseline conditions. Reductions in abortions due to brucellosis, hunter harvest, and increased winter mortality could affect bison recruitment. Overall, no substantial change in recruitment rates from those under baseline conditions would occur. This would be true even if a vaccination program was implemented, as increased recruitment that would otherwise be lost due to brucellosis-related abortion would be small.

There are no impacts at present from bovine tuberculosis or paratuberculosis. If these diseases became established in Jackson Hole, they would affect production and recruitment through increased mortality and lowering the number of animals that produce calves. These diseases could also affect age ratios because they would particularly increase mortality in older animals.
The potential number of clinical cases of bovine tuberculosis and paratuberculosis and losses in recruitment would be lower by a moderate amount under Alternative 3 due to lower prevalence, but this would constitute only a negligible increase in production and recruitment in the entire herd compared to Alternative 1.

**Mortality**

Increasing reliance on native forage and hunter harvest would increase mortality under Alternative 3 compared to Alternative 1.

Because supplemental feeding would only occur in severe winters, non-harvest mortality would be greater than the 5% per year under baseline conditions and Alternative 1, but would likely remain relatively low. Habitat enhancements outside the park and the refuge could reduce some of the potential increases in mortality due to lowered nutritional status. If Option A was selected, cultivating standing forage on the refuge would help mitigate the reduced frequency of winter feeding and related mortality. If Option B was selected and cultivated field were returned to native forage, additional mortality could result. It is also possible that increased distribution of remaining elk onto the northern portion of the refuge and in areas of the park closed to elk reduction might result in additional forage being available to bison, somewhat mitigating the effect on nutrition-related mortality rate increases.

Mortality due to vehicle collisions would be expected to increase from baseline conditions but would likely remain lower than under Alternative 1 because the bison herd would not continue to grow. Management removals would increase if more bison attempted to use areas outside the park and the refuge.

Predation on bison would increase negligibly in some years. Reliance on standing forage in above-average winters would lower physical condition in some animals, making them easier prey. This increase would likely be compensatory because some vulnerable bison would otherwise succumb to winter mortality. Calves, cows, and older bison would continue to be most vulnerable to predation.

A bison harvest on the refuge would be part of this alternative. In combination with harvest from Bridger-Teton National Forest, harvest of approximately 13% of the herd would be required to maintain bison at the target of approximately 1,000 animals, assuming bulls and cows would be harvested at even rates. This would be a major increase over current conditions (5%–7% harvest mortality) and could be larger than the harvest percentage under Alternative 1 (however, the degree of movement onto forest lands and hence vulnerability to harvest when the herd approached 2,000 animals under Alternative 1 is unknown). An assumption for analysis is that 50 bison would be harvested annually in the national forest and the balance would be harvested on the refuge.

Disease-related mortality, including abortions from brucellosis, and the relative potential for deaths from other diseases would be less under Alternative 3 than under Alternative 1 because of reduced potential for spread and reduced prevalence due to lower densities and numbers.

**Health, Sustainability, and Naturalness**

The health and sustainability of the Jackson bison herd would increase gradually as there was greater reliance on standing forage and wider ungulate distribution. This would improve both the genetic make-up of the herd and reduce the chance of major adverse impacts from the spread of disease. The prevalence of brucellosis would fall without vaccination, but would decrease even further if a safe and effective vaccine was used. Effects would be similar but more limited than what would occur under Alternative 2.

Barring the introduction of a serious non-endemic disease or extreme decreases in population size, the bison herd would continue to be self-sustainable and maintain genetic viability at about 1,000 animals. Higher mortality could occur in above-average winters, which would be exacerbated in some years by pre-winter drought. Overwinter mortality of the less fit might be expected to increase the frequency of beneficial genotypes and improve herd health (Mills, pers. comm. 2003), although to a lesser degree than under Alternative 2.
The long-term health and sustainability of the bison herd would be lower than under Alternatives 2 and 6 and higher than under Alternatives 1, 4, and 5.

Naturalness would also be enhanced as bison increasingly dispersed according to available forage, and environmental factors, such as winter weather and predators, would have an increasingly stronger influence on mortality. Mortality would increase in some years and more closely approximate mortality in non-fed herds. The size of the herd would be larger than, but closer to, the number that likely inhabited the valley prior to Euro-American settlement than under Alternative 1.

Naturalness would increase in terms of population processes, although to a lesser extent than under Alternatives 2 and 6. Production and recruitment rates would be more natural, and calves born outside the normal birthing season would be less likely to survive. Winter mortality rates would be closer to unfed populations, with more natural differences among age and sex classes. Bison would distribute themselves more naturally, expend more energy accessing winter forage, and maintain a more natural nutritional status.

Bison behavior would also become more natural. Competitive social interactions and displacement of elk and other bison from feedlines would decrease.

Harvest would have a minimal influence on the sex ratio because the bison population would be maintained at approximately 1 to 1 ratio of bulls to cows, typical of native, non-hunted herds.

Alternative 3 would result in a higher level of naturalness in the bison herd than would Alternatives 1, 4, and 5. Naturalness would be less than under Alternatives 2 and 6 mainly because of the continuation of winter feeding in some years.

Conclusion

In the long term under Alternative 3 there would be 1,000 or more bison in the Jackson herd. Numbers would be maintained at baseline levels and would be lower than in the long term under Alternative 1. Numbers would be higher than under Alternatives 2, 4, 5, and 6.

The bison herd would increase its movements and distribution due to reductions in years of supplemental feeding to approximately 2 years of 10 (roughly how often severe winters would occur). Increased winter mortality would result. The herd would be more responsive to natural conditions and the extent to which nutritional status reflects winter severity, precipitation regimes, and available forage would increase. Recruitment and annual survival could decrease to some extent compared to Alternative 1, although less than under Alternative 2. The sex ratio would remain near 1:1, and calf production and recruitment would be similar to levels found in non-fed populations in similar environments. Genetic viability would be sustained in a herd of 1,000 or more bison.

Reductions in density for both bison and elk, as well as in numbers of elk, would lower the risk of a disease quickly spreading and causing major impacts in the bison population.

A minor to moderate decrease in brucellosis prevalence in the bison herd related to increased dispersion and reductions in the frequency of supplemental feeding would occur. Vaccination with an effective vaccine to a large portion of bison calves each year could result in moderate reductions. This would only be possible with a vaccine administered through a biobullet or orally.

Alternative 3 would result in levels of long-term health, sustainability, and naturalness in the bison herd that would be lower than under Alternatives 2 and 6 and higher than Alternatives 1, 4, and 5.

Barring the introduction of serious non-endemic disease, Alternative 3 would not impair the bison population in the park. Alternative 3 would have a lower potential for impairment than under Alternatives 1, 4, and 5, and a higher potential than under Alternatives 2 and 6.

Alternative 4

Analysis

Bison Numbers

Reductions in the frequency of supplemental feeding and a bison hunt on the refuge and in the park would reduce bison numbers to a population of approximately 500. Assuming implementation in
2007, the herd by then would number about 1,000 bison, and harvest in the first few years would be higher than in the long term. An average of 70 bison per year would need to be harvested to maintain the herd at about 500 once this number was reached. After the initial implementation phase, the agencies would adaptively manage the bison and elk populations to achieve desired conditions, with animals predominantly relying on available native habitat on the refuge and in the park and forest, as well as on cultivated forage on the refuge.

**Distribution and Movements of Bison**

Reducing the supplemental feeding program would likely increase movements and distribution during non-feeding periods, and some years no supplemental feeding might be provided. Although bison would primarily use traditional areas, they would also range into Bridger-Teton National Forest to a greater degree, particularly following habitat enhancements by partner agencies. They could also travel southward, along the Refuge Road and near Jackson. Wider distribution within traditional areas could occur during non-feeding years, even with fewer bison.

Increases in distribution would likely be less than under Alternatives 2, 3, and 6. It is unlikely that the bison population would expand into the Gros Ventre River drainage. The agencies would work cooperatively with the Wyoming Game and Fish Department and landowners, including the local livestock community, to coordinate actions that would prevent conflicts due to bison dispersal and to defray costs of managing potential conflicts. Preventing bison access to food and hay would be vital for effective management.

Bison hunting would be initiated on refuge lands, but would continue to be prohibited in the park. A small number of bison might also be removed during tribal ceremonial events on the refuge. When these activities occurred, movements and distribution could change as bison moved away to safe, non-hunt areas on the refuge and in the park. If they moved onto private lands, WGFD personnel could exercise their prerogative to haze or destroy animals because of safety or damage concerns (WGFC regulations, ch. 41 (2002) and 15 (2004)).

Cultivated fields on the refuge would continue to attract bison, and the greater amounts of forage produced by enhanced irrigation and farming techniques would likely increase the time bison spent in those areas compared to baseline levels and Alternative 1. Prescribed fires on the refuge and in the park would also continue to enhance forage and habitat and would attract bison to treated areas, as under baseline conditions and Alternative 1.

Three exclosures, protecting approximately 1,000 acres of willow habitat in poor condition, 100 acres of remnant cottonwood communities along upper Flat Creek, and 1,000 acres of aspen habitat, would prevent access to approximately 9% of available acreage on the refuge. The shape of the aspen exclosure, wider east to west than north to south, could temporarily affect north-south bison movements (Cole, pers. comm. 2003).

Monitoring and adaptive management might indicate that these exclosures should be removed at some time. Exclosure design could be similar to designs under Alternative 6 (smaller exclosures that would be rotated, thus excluding ungulates from fewer acres) and bison movements and distribution would be similar to what would occur under Alternative 6.

RB51 would be used on bison in this alternative. Biobullet delivery from short distances appears to be an effective technique for elk vaccination and might be appropriate for use in bison if further research demonstrates that ballistic delivery provides adequate immunization. Ongoing studies could also identify better materials for producing biobullets and could indicate whether increasing the vaccine dose in biobullets would improve efficacy levels further (Olsen, pers. comm. 2004).

Hand injection would also be feasible for vaccinating the Jackson bison herd, although injection would require a longer period of time than would ballistic vaccination. The number treated would vary depending on associated procedures. If bison were immobilized and hand-injected, about eight could be treated per day. Winter feeding operations would help maximize success because large numbers are concentrated at the feeding areas and would be less likely to leave due to disturbance.
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Brucellosis vaccination with RB51 by WGFD personnel during winter supplemental feeding would cause short-duration, negligible to minor changes in movements and distribution similar to those described under Alternative 3 in “Distribution and Movements of Bison.”

**Bison Behavior, Social Interactions, and Nutrition**

Competition for standing forage during non-feeding periods would increase during the initial years of this alternative when bison and elk numbers would be similar to baseline numbers. Amounts of available herbaceous vegetation produced on the refuge would be negligibly lower (an estimated 4%) than under baseline conditions and the initial stages of Alternative 1 because of the exclosures. Over time, wider elk and bison distribution could decrease forage competition. Aggressive social interactions and displacements associated with supplemental feeding would decrease in the long term as the frequency of feeding declined.

In the long term nutritional status could be lower in some years than under baseline conditions and Alternative 1, although the decrease would have negligible adverse effects for the most part. In years when supplemental feeding occurred, nutritional status could be similar to baseline conditions and Alternative 1. Although exclosures would decrease the amount of herbaceous forage available to the herd, the amount per bison would increase in the long term because of lower numbers of both elk and bison, and because irrigation changes would help double cultivated forage in all years.

Changes in hunting practices would also cause short-duration adverse effects on bison behavior and possibly on nutrition. Implementing a refuge hunt could cause agitation, nervousness, and energetic expenditures among bison from avoiding hunters. Bison are not currently hunted on the refuge, but under this alternative, they would be hunted in all areas of the refuge open to elk hunting. Because bison hunting is also allowed in the Bridger-Teton National Forest adjoining the refuge, impacts on bison behavior and nutrition could continue as animals leaving the refuge to avoid hunters would continue to be susceptible to hunting on these lands. The prohibition on bison hunting would continue in the park.

Bison vaccination could cause some negligible impacts of airgun delivery to bison behavior, such as increased nervousness, excitability, and aggressiveness.

**Disease Prevalence and Transmission**

**Bovine Brucellosis**

*Prevalence in Herd* — In the long term, as reductions in supplemental feeding occurred and bison numbers were reduced on the refuge, bison would experience a negligible decrease in the prevalence of brucellosis compared to Alternative 1. The decrease would not be as great as under Alternative 3 because winter feeding would be more frequent.

As noted above, RB51 would be used on bison under this alternative because it is immediately available. Researchers generally agree that it would be safe for bison and non-target species (Davis and Elzer 1999, 2002). However, there is no consensus among researchers whether RB51 vaccination provides significant protection against abortion and infection in bison. Management efforts in Yellowstone National Park, where a vaccination program was recently begun using RB51 on non-pregnant yearlings and calf bison, would provide valuable information on the vaccine’s effectiveness in protecting against brucellosis in a field setting, although definitive results might not be available for years.

The above evaluation of negligible reduction in brucellosis prevalence in the Jackson bison herd would not change if RB51 had a low efficacy.

Based on modeling by Peterson, Grant, and Davis (1991b) of the Jackson bison herd, if RB51 had an efficacy of at least 25%–30% and if it was delivered to a high proportion of susceptible bison calves on the refuge every year, brucellosis prevalence would be expected to decline by that amount. Because the feeding program would continue, the effectiveness of vaccination would be reduced because possible contact with an aborted fetus or birthing materials would still be very high during feeding periods, and the decrease in prevalence would likely be negligible to minor. However, reduced feeding under Alternative 4, and fewer vaccination opportunities, could reduce prevalence negligibly. The degree that prevalence would decrease would depend on vaccine efficacy,
how frequently the herd could be vaccinated, and
the proportion of the herd treated. If a vaccine
(RB51 or other) with at least 50% efficacy was
available and delivered to a high proportion of
vaccine-eligible bison, then brucellosis could de-
crease by a minor to moderate amount.

Transmission among Bison — As noted in Alter-
native 3, transmission rates would likely only de-
cline by a negligible amount without vaccination
based on high prevalence numbers for free-
ranging herds and the gregarious nature of bison.
Transmission would remain high during feeding
years and would drop during non-feeding years
because the chances of encountering an aborted
fetus or birth site would decrease if bison were
more dispersed. Vaccination with a vaccine of 50%
efficacy would further reduce abortions and trans-
mission rates by a minor to moderate amount if
delivered annually, but it would be less effective if
delivered less often, and prevalence would be re-
duced by a negligible to minor amount. If the vac-
cine had a lower efficacy and was not given annu-
ally, reductions in prevalence would be negligible
at best.

Transmission from Elk to Bison — Reductions to
the supplemental feeding program, which could
include reductions in the frequency of feeding, as
well as numbers of both elk and bison, would re-
sult in a minor to moderate decrease in the risk of
transmission from elk to bison. This would be true
with or without vaccination.

Bovine Tuberculosis and Paratuberculosis

Both the risk of contracting either of these dis-
eases, and the degree of impact to the herd should
it become infected, would be midrange in the al-
ternatives. Because the frequency of feeding
would be more important in determining the risk
of transmission, bison would have a greater po-
tential for contracting these diseases under Al-
ternative 4, with a similar potential for impacts
should either become established, as described
above for Alternative 3.

Malignant Catarrhal Fever

Because feeding regimes and fewer numbers of
elk and bison would likely keep bison on the ref-
ge for the most part during the winter (during the
initial phase of the alternative), the risk of
contracting malignant catarrhal fever would be
low, and less than under Alternatives 1, 2, 3, and
6.

The panel of wildlife disease experts did not be-
lieve enough information existed to differentiate
potential impacts between Alternatives 3, 4, and 5
(Disease Expert Meeting 2002) if the disease be-
came established. The potential for adverse im-
acts under Alternative 4 would be similar to Al-
ternatives 3 and 5, greater than Alternatives 2
and 6, and less than Alternative 1.

Calving, Age and Sex Ratios, and Recruitment

Some negligible increase in mortality not related
to hunting would occur under Alternative 4, and
would primarily affect older bison and calves, or
bulls entering the winter energetically stressed
from rut activities.

The agencies would work cooperatively with the
Wyoming Game and Fish Department to establish
objectives for a bison sex ratio. The recommended
ratio recognizes that (1) natural immigrations
from other populations have been rare; (2) trans-
planting bison from other herds raises concerns
about diseases and other issues; (3) other herd
management constraints, including hunting, may
affect what sex ratio can be maintained.

The use of supplemental feeding would result in a
higher survival rate in calves than in unfed popu-
lations, although calf mortality would increase
beyond what it is under baseline conditions due to
reductions to the feeding program. Reductions in
abortions from brucellosis would also increase
recruitment by up to a minor amount. Hunter
harvest and increased mortality related to fewer
feeding years could diminish effects from in-
creases in calf recruitment due to a lower brucel-
losis prevalence, but it is also possible that overall
no substantial change in recruitment rates from
those under baseline conditions would occur. This
is true even if vaccination was implemented, as
increased recruitment in the segment of the herd
that would otherwise be lost due to brucellosis-
related abortion would be small.

If bovine tuberculosis or paratuberculosis infected
the population, increases in mortality would affect
both adults and calves. Because productive adults
would die, production rates would also decrease.
**Mortality**

A phased approach to reducing supplemental feeding, combined with increases in cultivated forage on the refuge, reductions in the bison and elk herds wintering on the refuge, and agency efforts to enhance habitat east of the refuge and park, would keep mortality unrelated to hunting low, although it would likely increase by a negligible amount over baseline conditions. A small increase in predation related to poorer body condition as a result of more reliance on available forage could occur during some years. Agency removals related to bison dispersing onto private land would likely increase initially in some years compared to baseline conditions until herd reductions brought the population closer to the objective level. Because the bison herd would grow indefinitely under Alternative 1, and agency removals would likely occur more frequently, Alternative 4 would have lower non-harvest mortality than under the no-action scenario in the long term.

Harvests would increase dramatically over baseline and no-action conditions. Currently, 40–50 bison are harvested each year from Bridger-Teton National Forest and private lands. Harvest would need to be increased to 140–150 bison per year to achieve the target number of about 500 bison within 10–15 years. This would be a 300% increase, a major short-term increase in mortality. Harvest would be maintained in the long term at about 70 bison per year once the population objective was reached, or about 30% higher than under baseline conditions.

Brucellosis-related abortions would decrease as prevalence dropped, and would further decrease if a safe and effective vaccine was applied to a large proportion of female calves.

If bovine tuberculosis or paratuberculosis infected the herd, potential increases in mortality would be moderately less than under the Alternatives 1 and 5 (and higher than other alternatives) because prevalence and the number of clinical cases would be moderately lower.

**Health, Sustainability, and Naturalness**

As in other alternatives that reduce the frequency of supplemental feeding, the health and sustainability of the Jackson bison herd would be increased gradually as a result of a greater reliance on standing forage and wider distribution. Impacts from current or new diseases would be reduced. A vaccination program would further reduce brucellosis transmission and prevalence. Health and sustainability under Alternative 4 would be less than under Alternatives 2, 3, and 6, and greater than under Alternatives 1 and 5.

Naturalness would also increase as bison increasingly distribute themselves according to the distribution of available forage on native range, and natural phenomena, such as winter weather and predators, would have a stronger influence on mortality in some years. Mortality and recruitment would be closer to those in non-fed herds. Bison would distribute themselves more naturally, expend more energy accessing winter forage, and maintain a more natural nutritional status. Sex and age ratios would be more natural, and sex ratios in particular would be maintained through a managed harvest to mimic unhunted, unfed herds. Bison behavior would also become more natural than under Alternatives 1 and 5, but less than under Alternatives 2, 3, and 6. Competitive social interactions and displacement of elk and other bison would decrease because there would be fewer elk and bison, wider ungulate distribution, and lower densities. Although bison numbers of about 500 could be higher than the number of bison that likely inhabited the valley prior to Euro-American settlement, it would be closer to what might have existed historically.

If adaptive management changes occurred after the initial implementation phase, health, sustainability, and naturalness could become more similar to what would occur under Alternative 6. The degree of similarity would depend on the extent of adaptive changes.

**Conclusion**

In the long term under Alternative 4 there would be approximately 500 bison in the Jackson herd, lower than baseline conditions or Alternative 1. The bison herd would increase its movements, distribution, and reliance on native winter range in some years due to reductions in the frequency of winter feeding. Increased winter mortality could result, although these increases would likely be negligible. The herd would be more responsive
to natural conditions, and the extent to which nutritional status reflected winter severity, precipitation regimes, and available forage would increase. Recruitment and annual survival could decrease compared to Alternative 1, although less than under Alternatives 2, 3, and 6. Genetic viability would likely be sustained in a herd of approximately 500 bison, although unrelated bison could be introduced into the herd if new research on genetics indicated that doing so was warranted.

Reducing supplemental feeding and initiating a bison hunt on the refuge would reduce bison numbers, increase distribution, and reduce potential disease transmission. Habitat enhancement efforts outside the park and refuge would also encourage wider bison distribution. Amounts of standing forage on the refuge would be decreased by a negligible to minor degree because greater use of exclosures would offset increases in refuge forage production on cultivated fields.

No impairment of park bison would occur under Alternative 4.

**ALTERNATIVE 5**

**Analysis**

**Bison Numbers**

The bison herd would gradually be reduced to 400 animals from the approximately 1,000 anticipated to exist at the signing of the Record of Decision (baseline conditions). Harvest on the refuge and in the national forest would lower numbers to the objective.

**Distribution and Movements of Bison**

Supplemental feeding would remain the same as in Alternative 1. Irrigation improvements would be used to increase cultivated forage on the refuge to help compensate for exclosures around woody vegetation. Although exclosures and cultivation could slightly modify bison distribution and movements of bison on the refuge, hunting would be the primary means under Alternative 5 to affect how bison would use the refuge during hunting season. Because the herd would eventually be much smaller than under either baseline conditions or Alternative 1, it would be more manageable, and intrusions onto private land or the town of Jackson to the south of the refuge would likely be minimal.

As in Alternatives 3 and 4, bison hunting would be initiated on areas open to elk hunting on the refuge and would supplement continuing harvest in the national forest and on private lands. Bison could move to safer areas on the refuge, such as Poverty Flats, and to the park, where hunting would continue to be prohibited. If bison moved to private lands, WGFD personnel could exercise their prerogative to haze or destroy them because of safety or damage concerns.

Increases in cultivated forage and prescribed fire on the refuge would continue to attract bison to these areas during feeding and non-feeding years. Exclosures up to 1,600 acres for willow, cottonwood, and aspen habitat would eliminate bison use of these areas. Monitoring and adaptive management could indicate that these exclosures should be removed at some time. In addition, the shape of the aspen exclosure, wider east to west than north to south, could hinder north-south bison movements. Although the fence would be designed to minimize this effect, concave areas of fence could temporarily stop bison and direct their movements (Cole, pers. comm. 2003).

RB51 would be used on bison in this alternative. Biobullet delivery from short distances appears to be an effective technique for elk vaccination and might be appropriate for use in bison if further research demonstrates that ballistic delivery provides adequate immunization. Ongoing studies could also identify better materials for producing biobullets and could indicate whether increasing the vaccine dose in biobullets would improve efficacy levels further (Olsen, pers. comm. 2004).

Hand injection would also be feasible for vaccinating the Jackson bison herd, although injection would require a longer period of time than would ballistic vaccination. The number treated would vary depending on associated procedures. If bison were immobilized and hand-injected, about eight could be treated per day. Winter feeding operations would help maximize success because large numbers are concentrated at the feeding areas and would be less likely to leave due to disturbance.
Impacts on the Jackson Bison Herd: Impacts of the Alternatives — Alternative 5

Brucellosis vaccination with RB51 would cause short-duration negligible to minor changes in movements and distribution similar to those described under Alternatives 3 and 4 in “Distribution and Movements of Bison.”

**Bison Behavior, Social Interactions, and Nutrition**

The frequency of social interactions, particularly aggressive interactions with elk, would decrease as bison numbers decreased.

Nutritional status could gradually be enhanced because amounts of standing forage available would increase as bison numbers were reduced and sprinkler irrigation expanded. Improvements in forage production through changes in irrigation practices on the refuge would offset the loss of herbaceous forage to exclosures. Overall, amounts of herbaceous vegetation annually produced in areas accessible to bison on the refuge would continue to be similar to, but negligibly lower than, baseline conditions (about 2% less) and about 0.5% lower than long-term conditions under Alternative 1. Because the bison herd would be dramatically smaller, available forage per bison would increase.

Vaccination activities would cause negligible to minor, short-duration, adverse effects to bison behavior and social interactions. If immobilization and hand injection were required, it would increase nervousness and excitability, energetic expenditures, and aggressive social interactions and displacements in some bison. Delivery of bio-bullets by airgun would have similar effects. Some injuries could result if bison were gored during these interactions. If oral vaccine delivery became possible and occurred outside the refuge feedground context, aggressive social interactions could increase at vaccine delivery sites because the vaccine would be delivered through a localized food source. If the oral vaccine was delivered during winter supplemental feeding, distribution and movements would remain similar to baseline conditions and Alternative 1.

RB51 vaccination activities could decrease the nutritional status in some bison to a negligible to minor extent due to increased energetic expenditure, disruption of feeding behavior, and reduced time spent eating.

**Disease Prevalence and Transmission**

**Bovine Brucellosis**

**Prevalence in Herd** — As noted above, RB51 would be used on bison under this alternative because it is immediately available. Researchers generally agree that it would be safe for bison and non-target species (Davis and Elzer 1999, 2002). However, there is no consensus among researchers whether RB51 vaccination provides significant protection against abortion and infection in bison. Yellowstone National Park’s management efforts, which recently began a vaccination program of non-pregnant yearlings and calf bison with RB51, would provide valuable information on the vaccine’s effectiveness in protecting against brucellosis in a field setting, although definitive results might not be available for years.

Compared to Alternative 1, brucellosis prevalence in the Jackson bison herd would not be altered to any large extent by vaccination in the short term under Alternative 5 if RB51 had a low efficacy.

Based on modeling by Peterson, Grant, and Davis (1991b) of the Jackson bison herd, if RB51 had an efficacy of at least 25%–30% and if it was delivered to a high proportion of susceptible bison calves on the refuge every year, the prevalence of brucellosis could be expected to decline by an estimated 25%–30% (Peterson, Grant, and Davis 1991b). However, the feeding program would hinder the effectiveness of vaccination because the chance of contact with an aborted fetus or birthing materials would still be very high. Therefore, only a minor reduction in prevalence in the herd could be expected. Because the effectiveness of RB51 on free-ranging bison is unknown, prevalence could be greater or less than at present.

**Transmission among Bison** — Transmission potential would remain high in this alternative because supplemental feeding would continue to provide ample opportunities for contact with infected fetuses or birthing materials. If RB51 proved to be more effective than research indicates (above 50%, for example), a minor reduction in transmission would occur because of lowered prevalence.

**Transmission from Elk to Bison** — If Strain 19 reduced brucellosis prevalence in elk, transmission from elk to bison would decrease by a
negligible degree. This would be because (1) a high proportion of a relatively small herd (compared to Alternative 1) would still have the potential for contact with elk while on feedlines, and (2) a single abortion (which could occur even when prevalence is low) could infect a large proportion of bison in the feedground area.

**Bovine Tuberculosis and Paratuberculosis**

The risk that bovine tuberculosis or paratuberculosis would become established would remain high under Alternative 5 because of the frequency of winter feeding. Risk would be lower than under Alternative 1, but higher than all other alternatives. The potential prevalence in the herd could be lower by a negligible to minor amount compared to Alternative 1 because bison numbers would be reduced. This reduction in numbers and hence density of bison would also reduce the potential for transmission between bison.

**Malignant Catarrhal Fever**

The risk of infection in the Jackson bison herd under Alternative 5 would be similar to the risk under Alternative 4, and less than under the other alternatives because the amount of forage and feeding relative to the number of bison would encourage elk and bison to remain on the refuge during winter, thus avoiding contact with potentially infected domestic sheep. The potential for impacts under Alternative 5 would be similar to those under Alternatives 3 and 4, greater than under Alternatives 2 and 6, and less than under Alternative 1.

**Calving, Age and Sex Ratios, and Recruitment**

Continuing to feed bison during the winter would result in higher-than-natural calf survival rates during winter. This would be unchanged from Alternative 1.

Although hunting could affect both age and sex ratios, the U.S. Fish and Wildlife Service and the National Park Service would work cooperatively with the Wyoming Game and Fish Department to annually adjust hunting regulations and licensing to maintain age and sex ratios similar to those in unhunted and unfed populations.

In the short term, production and recruitment would be unaffected by changes in brucellosis prevalence. As RB51 vaccinations began to take effect, there could be associated minor reductions in abortions, and recruitment could increase. This reduction in calf loss would have a negligible beneficial impact on the overall production and recruitment in the Jackson bison herd in the long term, because current production losses from brucellosis are estimated to be low.

If bovine tuberculosis or paratuberculosis became established, they would affect production and recruitment indirectly through increased mortality, although they would not affect the production rate. The number of calves produced each year would decline with a declining population size and fewer adult females. Bovine tuberculosis and paratuberculosis could affect age ratios because mortality would increase particularly in older animals.

**Mortality**

Non-harvest mortality would remain similar to baseline conditions because supplemental feeding would continue to occur in almost all years. Because the smaller herd would likely stay on the refuge during winter, fewer agency removals or vehicle collisions would occur than under Alternative 1.

Harvest mortality, particularly in the short term, would increase dramatically over baseline conditions and Alternative 1. The current harvest of 40–50 bison would be increased to 150–155 bison per year to achieve the target number of 350–400 in 10–15 years. This would be more than a 300% increase, a major short-term increase in mortality. Harvest would be maintained in the long term at about 40–80 bison per year once the population objective had been reached, a moderate increase over baseline conditions.

Rates of predation would remain very low, affecting the herd to a negligible extent and similar to baseline conditions and levels under Alternative 1. The actual number of bison preyed on would decrease because of fewer bison and fewer opportunities for predation.

If bovine tuberculosis or paratuberculosis infected the smaller Jackson bison herd, mortality would
be less by a negligible to minor amount compared to Alternative 1.

**Health, Sustainability, and Naturalness**

The health and sustainability of the Jackson bison herd would be similar to levels under baseline conditions and Alternative 1. High ungulate concentrations during nearly annual winter feeding would increase the potential for the spread of disease. Although bison numbers would gradually be reduced to 400, Alternative 5 would concentrate thousands of elk and hundreds of bison on feedlines for several months nearly every year. These annual concentrations would provide conditions under which a new disease could spread rapidly, jeopardizing herd health and sustainability in the long term. Winter nutritional status would remain unchanged, but could improve in the summer as both elk and bison densities were reduced, particularly in the Grand Teton elk segment. Brucellosis vaccination (if the RB51 vaccine was 25%–30% effective) would decrease prevalence to a minor degree in the long term.

Barring the introduction of serious non-endemic disease, the herd would continue to be genetically viable at 400 animals. If the herd was maintained below 400 bison post hunt, unrelated bison could be introduced periodically to maintain genetic viability.

Due primarily to elevated disease risks and increased genetic contributions from less fit animals, long-term health and sustainability of the bison herd under Alternative 5 would be lower than under Alternatives 2, 3, 4, and 6, and greater than under Alternative 1.

Naturalness would remain similar to baseline conditions and Alternative 1, where several population processes would continue to operate at unnatural levels. Notably, winter mortality would be much lower than natural due to the winter feeding program on the refuge. Under natural conditions, mortality rates are different among age and sex classes, but winter feeding would tend to nullify these differences. Bison would continue to expend less energy accessing winter forage than they would without supplemental feeding, and they would continue to maintain a higher level of nutrition in winter. Also because of the winter feeding program, recruitment rates would be unnaturally high and calves that are born out of the normal calving season would continue to have a high chance of survival. Several of these factors could affect long-term fitness of the herd.

Because it is probable that at least some bison migrated out of Jackson Hole before they were extirpated in the mid-1800s, and because bison are now year-round residents, their seasonal distribution and movements would continue to be unnatural under Alternatives 5 and 1. Rather than many groups of bison roaming in search of available forage, as would have occurred naturally, the herd would now continue to be concentrated in a relatively small area for several months each winter.

Although harvest would increase under Alternative 5, harvest would continue to have a minimal influence on the sex ratio because annual adjustments would be made to maintain an approximately equal bull-to-cow ratio, typical of non-hunted herds. In addition, the size of the bison herd after herd reductions occur in the short term would probably be closer to the number of bison that inhabited the valley prior to Euro-American settlement, especially in winter compared to numbers under Alternative 1.

Overall, naturalness under Alternative 5 would remain similar to Alternative 1 and would be lower than under Alternatives 2, 3, 4, and 6 because of the continuation of winter feeding.

**Conclusion**

In the long term under Alternative 5 there would be about 400 bison in the Jackson herd, lower than baseline conditions and Alternatives 1, 3, and 4. Numbers would be higher than under Alternative 6 and could be similar to numbers under Alternative 2.

Nutritional status would remain high due to nearly annual supplemental winter feeding and recruitment, and annual survival would remain high as compared to a non-fed population. The sex ratio would likely remain near 1 to 1.

The risk for a non-endemic infectious disease quickly spreading through the bison herd and causing major adverse impacts would be similar to Alternative 1 due primarily to the near-annual winter feeding program. However, the risk would
be somewhat reduced because of a smaller herd. The severity of potential impacts from a non-endemic infectious disease on survival, population size, and sustainability would be somewhat lower than Alternative 1, and higher than Alternatives 2, 3, 4, and 6. RB51 could reduce brucellosis prevalence by up to a minor degree.

Alternative 5 would result in levels of long-term health, sustainability, and naturalness that would be somewhat higher than Alternative 1 and lower than Alternatives 2, 3, 4, and 6.

There would be no impairment of park bison under this alternative. If the population dropped below the level considered to be genetically viable, bison would be carefully screened and imported to add diversity.

**ALTERNATIVE 6**

**Analysis**

**Bison Numbers**

The approximately 1,000 bison existing at the time the Record of Decision is signed would be gradually reduced to about 500 animals through hunting and the elimination of winter feeding.

**Distribution and Movements of Bison**

Reductions in winter feeding would take place over a 5-year period, or immediately if mild weather conditions allowed rapid program changes. Hunting would begin on the refuge, with initial harvest of about 150 animals per year. Both of these factors would change distribution and movements of bison.

As reductions in and elimination of supplemental feeding took place, winter distribution would be expected to increase due to reliance on native forage. Based on environmental conditions, results of a forage availability model (Hobbs et al. 2003) indicated that ungulates could winter best in the Gros Ventre River drainage and south of Jackson in the Snake River Valley, particularly near Alpine and including lower portions of Hoback Canyon. Habitat improvements by partner agencies would also occur east of the refuge. If conservation easements could be obtained in the analysis area, bison could move into them as well.

Bison hunting would be initiated on lands open to elk hunting on the refuge, in addition to ongoing hunting in Bridger-Teton National Forest and on private lands. Hunting could occur in the south end of the refuge as well as in traditional elk hunting areas on the northern end. In addition to a public hunt in the fall, tribal reductions would also be initiated. The prohibition on bison hunting in the park would continue. Allowing bison hunting on parts of the refuge could redistribute animals to unhunted portions of the refuge or into the park. Particularly as numbers decreased, bison would be less likely to travel south toward the town of Jackson. Some could find native forage outside the refuge and park and travel to these areas during the fall or winter, but permanent colonization would be unlikely. Because private lands are interspersed with national forest lands, and because elk feedgrounds are present in these areas, free-ranging bison would be hunted or removed by the state because of threats to public safety, property, or the health of domestic livestock (WGFC regulations, ch. 41 (2002) and 15 (2004)).

After the objective for the bison herds was reached, bison hunting on the refuge could be decreased or eliminated if monitoring indicated that adequate harvest could be achieved outside the refuge. Some bison would redistribute to areas closed to hunting.

Bison movements on the refuge would also be negligibly altered by a variety of exclosures in the short term. Refuge exclosures protecting 100 acres of remnant cottonwood along upper Flat Creek and other exclosures of varying size sequentially protecting approximately 600 acres of aspen in different areas during three consecutive periods in the short term would prevent access to these parts of the refuge.

After bison numbers had been reduced to about 500 and supplemental feeding had been eliminated, brucellosis vaccination could occur if safe vaccines were developed that had a minimum efficacy of 50% for both bison and elk and that could be delivered ballistically or orally for both bison and elk. (Ballistic delivery would not be feasible for elk in the park because they are widely distributed in the summer.) Both forms of delivery could be administered to bison in the park (and to elk on the refuge).
Ballistic vaccination would cause negligible to minor short-duration increases in movements and distribution. Because hunting would be coincidental with vaccination, the herd would be likely to react more strongly to the use of airguns. Acclimation and therefore success in vaccinating bison could be lower than in alternatives where no hunting would be allowed. Vaccination would also be made more difficult because bison would not be concentrated along feedlines.

If a sufficiently effective oral vaccine is developed that would be safe for elk and bison as well as non-target species, and could be delivered through localized food supplementation, vaccine delivery could temporarily change distribution by a negligible to minor extent.

**Bison Behavior, Social Interactions, and Nutrition**

Relatively rapid reductions in supplemental feeding and numbers of elk and bison would reduce competitive social interactions associated with feedlines to fewer years. However, competition for native forage and associated aggressive social interactions would increase, particularly in the short term before the herds were reduced. In time, wider ungulate distribution would diminish forage competition.

Elk would be redistributed on the refuge despite fewer elk and bison because supplemental feeding would be eliminated. Elk would be more likely to move to areas with less desirable forage to avoid conflicts with bison. Competition under Alternative 6 would be lower than what would likely occur under Alternative 1 with continued growth of the bison herd. If oral vaccine delivery became possible, aggressive social interactions could increase at vaccine delivery sites because the vaccine would be delivered in the food.

The implementation of bison hunting on the refuge could temporarily cause agitation and nervousness, increased energetic expenditures associated with avoiding hunters and the sounds of weapons firing, and possibly lower nutrition because they would stop foraging when leaving these areas. In the long term closures of the northern portion of the refuge to bison and/or elk hunting would reduce these behaviors.

The nutritional status of bison could be reduced by the rapid phasing out of winter supplemental feeding. With supplemental feeding in fewer winters and bison relying on native forage during increasingly severe winters, nutritional status could decrease depending on winter severity and access to forage. Because bison and elk numbers would be reduced through harvest and would be more widely distributed, decreases in nutritional status could be negligible to minor compared to baseline conditions and Alternative 1. Nutritional status under Alternative 6 would more closely mimic free-ranging, non-fed bison populations, similar to Alternative 2. Although some bison could die during above-average and severe winters because of decreased nutrition and body condition, at low numbers most might be able to maintain adequate nutritional levels on native forage. There could be more malnutrition, increased use of woody vegetation in severe winters, and moderate to major increases in mortality in severe winters compared to baseline levels.

Forage would continue to be cultivated for up to 15 years to help mitigate the loss due to enclosures to protect woody vegetation and the phase-out of supplemental feeding. Amounts of total herbaceous forage produced on the refuge would be greater than under baseline conditions (8% more) and about 11% greater than amounts under long-term conditions in Alternative 1. Minor increases in available forage, combined with moderate decreases in elk numbers and moderate to major decreases in bison numbers, might provide adequate nutritional levels during most years. After 15 years irrigation practices would be evaluated and potentially reduced if more than adequate amounts of forage were being produced for elk and bison on the refuge. Loss of supplemental food would be partially mitigated through habitat enhancement efforts in Bridger-Teton National Forest.

If effective brucellosis vaccines were developed, vaccination activities would cause negligible to minor short-duration adverse effects due to disruption of normal bison behavior. If the vaccines were delivered ballistically, bison could experience increased nervousness and excitability. Energetic expenditures from running and aggressive social interactions and displacement of elk would increase. Delivery of an effective oral vaccine would temporarily change distribution in a non-
fed herd. Changes in bison distribution and densities at vaccine delivery sites could cause short-duration, localized increases in aggressive social interactions.

**Disease Prevalence and Transmission**

**Bovine Brucellosis**

*Prevalence in Herd* — As the high densities associated with feedlines would no longer occur and bison would be more widely dispersed, brucellosis seroprevalence would decrease by a moderate amount. Modeling has illustrated that bison populations as small as 200 animals can maintain brucellosis (Dobson and Meagher 1996), so brucellosis would not be eliminated from the herd.

*Brucellosis Transmission among Bison* — Eliminating winter feeding, and associated reductions in density and potential for contact with aborted fetuses, would result in a major reduction in the transmission of brucellosis among bison on the refuge. Potential use of a vaccine in the long term, if one was developed that had an efficacy of greater than 50% and that could be administered orally or ballistically, would add to this reduction.

*Brucellosis Transmission from Elk to Bison* — The possibility of transmission of brucellosis from elk to bison would be reduced by a moderate to major degree as both elk and bison dispersed more widely, and numbers and chances of contact were reduced.

**Bovine Tuberculosis and Paratuberculosis**

The risk that either bovine tuberculosis or paratuberculosis would become established would be low, similar to the risk under Alternative 2. If either disease became established, prevalence and transmission would be lower by a major amount than under Alternative 1 due to reductions in density and numbers of bison. This would also be true of the potential for transmission from elk to bison.

**Malignant Catarrhal Fever**

The risk of contracting malignant catarrhal fever would be greatest under Alternatives 2 and 3 because elk could migrate to other areas, and elk and bison would run the highest risk of contact with infected domestic sheep. Although support for migration to other wintering areas is not part of Alternative 6, dispersal likely would increase, and the risk would be higher than under Alternatives 1, 4, and 5.

If malignant catarrhal fever became established, animal density would be the primary factor influencing impacts. Hence, the potential for impacts would be lowest under both Alternatives 2 and 6.

**Calving, Age and Sex Ratios, and Recruitment**

Increasing reliance on native winter range would affect body condition and would likely result in the loss of older bison, calves, and energetically stressed bison, including prime bulls that have just completed the rut. In the long term this would create more natural sex and age ratios. After objectives for herd reductions were reached, hunting strategies would be designed to restore and maintain more natural age and sex ratios to minimize impacts that would otherwise occur if harvest strategies were not adaptive.

Initially, the bison hunt would focus on reducing numbers and potential productivity of the herd, as well as the risk of abortion and brucellosis transmission. Therefore, adult female bison between 2 and 4 years old would be particularly targeted. This would temporarily alter sex ratios, particularly if the harvest of young females was adequate to meet herd reduction objectives. After the bison herd was at objective and brucellosis prevalence was reduced, further adjustments to annual harvest would be made to minimize effects and achieve more natural age and sex ratios.

Recruitment under Alternative 6 would likely be lower in the long term compared to Alternative 1, although not to the same extent as Alternative 2.

The infection of the herd by bovine tuberculosis or paratuberculosis would affect production and recruitment through increased mortality of reproducing adults. These diseases could also affect age ratios because they would increase mortality particularly in older animals.

If bovine tuberculosis or paratuberculosis infected the herd, the dispersion and lower numbers associated with this alternative would mean major decreases in production losses compared to Alter-
Impacts on the Jackson Bison Herd: Impacts of the Alternatives — Alternative 6

However, the absolute impact of these diseases on production in the herd would be low. As an example, if prevalence of bovine tuberculosis or paratuberculosis was 50%, and 5% of those developed clinical disease, then a maximum of 2.5% of the potential calf production could be retained; this would constitute a negligible increase in production and recruitment.

Mortality

Winter mortality not related to hunting would gradually increase under Alternative 6 as supplemental feeding was reduced and bison relied more on standing forage. The reduction of bison numbers, the continued cultivation of forage on the refuge, and habitat enhancements outside the park and refuge, along with possibly closing the northern portion of the refuge to bison and elk hunting as well as the southern end of the park to elk herd reduction in the long term, would increase available forage.

Because bison distribution would increase in the short term due to reductions in the supplemental feeding program, the movement to native winter range, and the addition of new hunt areas, the total number of management removals would be expected to rise as more bison sought additional food sources, possibly resulting in more conflicts on private lands. These bison movements could increase the number of bison deaths from vehicle collisions.

Overall, non-harvest mortality would be greater than 5% per year under baseline conditions and Alternative 1 due to supplemental feeding but would likely be less than under Alternative 2.

Harvest mortality, particularly in the short term, would increase dramatically over baseline conditions and Alternative 1. The current harvest of 40–50 bison from Bridger-Teton National Forest and private lands would be increased to 200 bison per year to achieve the target number of 500 in five years (a 300%–400% increase). This would be a major short-term increase in mortality. Possibly fewer bison would need to be harvested to meet the herd objective if enough reproductive females were taken to affect production rates. Once the population objective was reached, harvest would be about 60 bison per year, a moderate increase over baseline conditions.

Predation on bison would increase negligibly but this increase would likely be compensatory. Calves and older bison would continue to be the most vulnerable to predation.

A moderate reduction in disease prevalence due to lower bison numbers and no winter feeding would decrease the number of abortions related to brucellosis.

If bovine tuberculosis or paratuberculosis infected the Jackson bison herd, the potential for mortality would be less under Alternative 6 by a moderate to major degree compared to Alternative 1 because of a smaller herd. Both of these chronic diseases do not kill their host for many years, if at all.

Health, Sustainability, and Naturalness

Long-term health and sustainability of the bison herd under Alternative 6 would be similar to these qualities under Alternative 2 and higher than all other alternatives.

The health and sustainability of the Jackson bison herd would increase as supplemental feeding was eliminated and there was greater reliance on standing forage. Increased forage production on cultivated areas of the refuge while bison numbers were decreased through hunting would help prevent starvation and contribute to herd health and sustainability. Lower ungulate concentrations would also result in lower disease prevalence and transmission of current diseases, such as brucellosis, as well as the likelihood of major impacts from new diseases.

Herd health would be further improved if a safe and effective vaccine for brucellosis was developed and could be delivered to a large proportion of the population’s calves.

Barring the introduction of a serious non-endemic disease, the bison herd would be self-sustaining at 500 (based on a five-year running average). Harvest levels would be adjusted to allow some natural fluctuations in herd size while maintaining this objective. Herd numbers would vary to some extent due to higher natural mortality in above-average and severe winters.

The bison herd would be more natural compared to baseline conditions and Alternative 1 due to the
elimination of winter supplemental feeding and increased reliance on native forage. Natural factors such as climate and forage availability would have a much greater influence on numbers, movements, distribution, and winter mortality. Bison numbers would be closer to the low number of bison that likely inhabited the valley prior to Euro-American settlement than they would under Alternative 1. Human-related deaths (such as vehicle collisions) would likely decrease once bison numbers were at objective levels.

Production and recruitment rates would be more natural, and calves born outside the normal birthing season would be less likely to survive. Winter mortality rates would be more typical of an unfed population and would differ among age and sex classes in a more natural way. Bison would distribute themselves more naturally, expend more energy accessing winter forage, and nutritional status would be reflective of fluctuating environmental conditions.

Bison behavior would also become more natural. Competitive social interactions associated with feedlines and the displacement of elk and other bison would decrease because there would be fewer elk and bison, wider ungulate distribution, and lower densities. Competition over forage would continue to occur in localized areas and would increase in winters of greater severity.

Although harvest levels would increase under Alternative 6, the effect on health and sustainability of the herd would continue to be negligible. In the long term harvest levels would be used to maintain a 1 to 1 sex ratio indicative of a non-hunted herd.

Alternative 6 would result in a higher level of naturalness in the bison herd than would Alternatives 1, 3, 4, and 5. Naturalness would be similar to Alternative 2 because of the elimination of winter feeding.

Conclusion

In the long term under Alternative 6 there would be 500 bison based on a five-year running average in the Jackson herd. Numbers would be lower than under Alternatives 1 and 3 (baseline conditions), and similar to numbers under Alternatives 4, 5, and 2 (if numbers were at the higher end of the expected range under Alternative 2).

Phasing out supplemental winter feeding would cause bison to disperse more widely in search of native forage. The herd would become more responsive to environmental conditions, and winter mortality would fluctuate with winter severity, precipitation regimes, and standing forage. Recruitment and annual survival would decrease compared to Alternative 1. Although intensive age-biased harvest in the short term would temporarily alter age and sex ratios, harvest would be adjusted in the long term to maintain more natural ratios. In the long term, the sex ratio and calf production and recruitment would be similar to levels found in non-fed populations in similar environments.

The risk of a non-endemic infectious disease quickly spreading through the herd would be the lowest (along with Alternative 2) of any alternative due to the elimination of the nearly annual winter feeding program and fewer bison and elk. Alternatives 2 and 6 would have the lowest risk of such a disease having major adverse impacts to survival and population sustainability. The prevalence of brucellosis in the bison herd would be moderately lower than under Alternative 1.

Alternative 6 (along with Alternative 2) would result in higher levels of long-term health, sustainability, and naturalness in the bison herd than what would occur under Alternatives 3, 4, and 5.

No impairment of park bison would occur.

MITIGATION

Mitigating measures for impacts on bison were incorporated into the alternatives and the impact analysis.

CUMULATIVE EFFECTS

TRANSPORTATION IMPROVEMENTS

The reconstruction of U.S. 26/287 west of Togwotee Pass would likely not affect bison by decreasing available habitat or increasing vehicle collisions because Jackson bison are rarely found in this area. Under Alternative 1 the bison herd would be expected to grow to at least twice its current size (approximately 1,000 animals), perhaps to as large as 2,000 animals. Although bison have remained primarily within the park and the
refuge, a herd of this size could expand its range, and individuals could move into the highway reconstruction area. Upgrading the existing highway would not be expected to result in extensive effects in terms of blocking movements, and it is anticipated that effects on overall herd dynamics would be minimal. Alternatives 2–6 would not result in cumulative effects that would contribute to effects of the reconstruction effort.

**FEDERAL LAND MANAGEMENT ACTIVITIES**

**Grand Teton National Park Fire Management**

Mechanical fire management treatments could result in a small reduction in bison habitat, reduce habitat quality, and create short-term disturbance effects that could displace more mobile animals in proximity to Wildland Urban Interface (WUI) areas. However, these actions are not expected to adversely affect bison at a population level because habitat effectiveness in these areas and the immediate vicinity have already been reduced. WUI areas represent a small part of habitat available to park wildlife, and the vast majority of wildlife habitat in Grand Teton National Park occurs outside developed areas.

Prescribed fire can be used to maintain and restore more diverse vegetative communities in landscapes where natural fire regimes have been disrupted. Prescribed fires could in the short and long terms alter plant communities and displace individual bison from certain portions of habitat, but the long-term effect would be to create vegetative diversity that favors native wildlife species. None of the alternatives would result in cumulative effects on bison.

**Grand Teton National Park Recreation Infrastructure Improvements**

The proposed implementation of multi-use pathways, the realignment of portions of the Moose-Wilson Road, and other transportation improvements would result in site-specific, temporary impacts along planned improvement routes during the summer. The finished trail would attract additional recreationists along the Snake River corridor during the summer and possibly cross-country skiers in the winter.

The trail construction phase would likely displace individual bison within or near work areas in the short term and make habitat unavailable. If pathways were separate from existing roads, long-term impacts to bison could include loss of habitat, loss of the use of habitat near the new pathways, and changes in movements and distribution. Improved human access to parts of the park could increase levels of disturbance to bison and alter distribution and habitat use.

Any future improvements to the Gros Ventre campground would result in site-specific, temporary impacts during construction. This action could increase disturbance to bison in summer and could alter distribution and habitat use, as well as bison/human conflicts. Effects would likely be negligible because habitat effectiveness has already been reduced in this area.

The greatly increased number of bison in the Jackson herd under Alternative 1 would result in more encounters between bison and humans, in addition to impacts from park infrastructure improvements. Alternatives 2–6 would not result in cumulative effects because of a smaller herd size compared to Alternative 1.

**Grand Teton/Yellowstone National Parks and John D. Rockefeller, Jr., Memorial Parkway Temporary Winter Use Plan**

The total number of snowmobiles allowed into the park would be similar to historical levels but, because all visitors would be traveling in guided groups, oversnow vehicle users would be less likely to interact with wildlife, causing less mortality, less stress, less displacement, and fewer population-level impacts. The impacts would not be of sufficient magnitude to constitute impairment of bison.
No cumulative impacts to bison on adjacent lands outside the park are anticipated under the alternatives. Despite the larger herd size under Alternative 1, winter distribution would largely be confined to the refuge.

**Bridger-Teton National Forest Fuels Management Projects**

Projects identified by the Bridger-Teton National Forest that would occur nearest to park and refuge boundaries could affect bison under Alternative 1 due to potential range expansion in seasons other than winter. These projects could temporarily diminish forage opportunities directly following various fuel reduction treatments. However, in the long term most of these projects would improve transitional and winter habitats. No cumulative impacts to bison on adjacent lands are anticipated under the alternatives.

**Population Growth and Private Land Development**

Projected population increases in Teton County over the next 15 years would continue to create a demand for private land development. Bison would be present only in the primary analysis area. Habitat loss and increased potential for bison/human encounters, conflicts, and vehicle collisions could occur.

Additional development on private lands in the Buffalo Valley area would be outside the baseline winter range for bison and would not affect them. Under Alternative 1 additional development of private parcels along the Gros Ventre River could increase conflicts between humans and bison if they moved into this area. Alternatives 2–6 would not contribute to the effects of private land development on bison.