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CHAPTER 3. AFFECTED ENVIRONMENT

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INTRODUCTION

The affected environment describes those portions of the natural and human environment that could be affected with the implementation of any of the management alternatives. The following impact topics were dismissed from further consideration because either there would be no impacts, or impacts would be negligible or not detectable, as discussed below:

Air Quality — Impacts on air quality as a result of actions under all the alternatives (e.g., disking fields, reducing winter feeding, or discontinuing farming) would be negligible, and impacts on Jackson Hole air quality would not be detectable. Impacts of discontinuing prescribed fire on the refuge under Alternative 2 would result in temporary, negligible impacts, but allowing naturally ignited fires to burn, as long as public or private facilities were not threatened, could adversely affect air quality depending on the size of the fire and environmental conditions at the time. Potential effects of prescribed burning programs on the refuge and in the park were evaluated in separate environmental assessments (NPS 2004b; USFWS 2002b).

Sound and Noise — Ambient noise on the National Elk Refuge is primarily from the town of Jackson and traffic on U.S. 26/89. Noise sources on the refuge include vehicles and refuge operations (such as feed operations and maintenance activities), and to a lesser degree recreational activities. In Grand Teton National Park nonnatural noise sources in and near the project area include traffic along U.S. 26/89 and Teton Park Road, arriving and departing commercial and private aircraft at Jackson Hole Airport, and snowmobile engines.

Potential effects on sound resources from management activities and equipment would be the same as existing conditions. Noise impacts from converting to sprinkler irrigation were evaluated in the *Irrigation System Rehabilitation Plan Environmental Assessment* (USFW 1998). Other noise impacts associated with the management alternatives would be negligible. While noise levels on the refuge could increase due to development and population growth in and around Jackson, this is beyond the scope of this document.

Threatened, Endangered, or Special Concern Species — The following species would not be affected by actions considered in this environmental impact statement.

- *Lynx* — Lynx, a threatened species, is primarily an inhabitant of high elevation, moist coniferous forests that support subalpine fir, Engelmann spruce, and lodgepole pine trees. They also use riparian corridors to travel (Kaminski, pers. comm. 2003). Little is known about this cat, but to the extent that riparian corridors were preserved, lynx could benefit. Lynx primarily feed on snowshoe hares and red squirrels; while they may occasionally feed on elk and bison carrion, it is a small part of their diet. Lynx are thought to be very rare in the park and do not occur on the refuge because there is no suitable habitat. A change in numbers and distribution of elk and bison would have no more than a negligible impact on lynx.
- *Trumpeter Swan* — Trumpeter swans are classified as a priority 1 species of special concern in Wyoming (Fertig and Beauvais 1999) and as a sensitive species in U. S. Forest Service Regions 2 and 4. Trumpeter swans nest on the National Elk Refuge and in Grand Teton National Park, and there may be as many as 200 trumpeters on the refuge during fall migration; 50 trumpeter swans may winter on the refuge. In 2004 three pairs of swans on the refuge fledged nine cygnets (NER files). In 2004, 7 of the 10 historic nesting sites in Grand Teton National Park were occupied, and nesting was attempted at 5 of these sites. Only two nests produced cygnets, and four of these cygnets survived to fledge (NPS 2004d). Marshland habitats used by trumpeter swans are not expected to be affected or would be affected to a negligible degree by actions being considered in this planning process. Therefore, impacts on trumpeter swans were not analyzed in detail.
- *Wolverine* — Wolverines are considered rare in most areas, including Grand Teton National Park and the National Elk Refuge. Radio-collared wolverines occasionally are

monitored moving across the Teton Range from Idaho, where they have been captured and marked, to Jackson Hole (Inman, pers. comm. 2004). Wolverines appear to rely heavily on carrion of any kind, but are not likely to move into ungulate winter range during the winter (Copeland, pers. comm. 2003). They remain at high elevations and consume carrion generally made available during summer and fall (largely hunter-related mortality). Wolverines live at relatively low densities, allowing a population to persist with limited resources. As long as there is a viable population of elk in the area, wolverines would not be negatively impacted by the numbers of elk that are projected under any alternative.

- *River Otter, Fisher, and American Marten* — River otters, fishers, and American martens are occasionally seen in the Jackson Hole area, the Green River basin, and the Red Desert. It is not anticipated that these species would be affected by actions considered in this document.
- *Whooping Crane* — The whooping crane *(Grus americana)* is one of the rarest animals in North America and is federally listed as endangered. The resident status of whooping cranes historically in the greater Yellowstone ecosystem is in question, and they no longer exist in the Rocky Mountains. The last two cranes in the flock at Gray's Lake National Wildlife Refuge disappeared in the fall of 2001 (Fisher, pers. comm. 2002). The remaining flocks, numbering no more than 400 birds, occur in Texas, central Florida, and central Wisconsin.

Other Ungulates — Mountain goats have been introduced to the Jackson Hole ecosystem, and there is little habitat overlap with bison and elk (Chadwick 1983). White-tailed deer are not abundant in Jackson Hole. Consequently, neither species is discussed in detail.

Fish — The fish community in Jackson Hole is typical of cold waters, and only 18 species are present. Bison and elk can potentially affect fish habitat by reducing water quality, eroding streambanks, and suffocating spawning beds. Heavy browsing of riparian vegetation by elk and bison may raise water temperatures by removing shady vegetation. However, most fish populations in the Jackson Hole area are doing well, and these effects are relatively minor or nonexistent. Therefore, fish are not further discussed.

Cultural Resources

- *Historic Structures* — The Miller house (48TE903), a homestead cabin on Refuge Road in the southern portion of the National Elk Refuge, together with the barn, are the only recorded historic structural resources on the refuge. They are listed on the National Register of Historic Places. No actions considered in this environmental impact statement would affect them.

  Grand Teton National Park has 318 historic structures listed on or eligible for listing on the National Register of Historic Places. No structures would be adversely affected by actions considered under this plan.
- *Cultural landscapes* — A cultural landscape is a geographic area, including both cultural and natural resources that are associated with an historic event, activity, or person and that exhibits other cultural or aesthetic values. While landscapes are not fixed in time and continue to evolve, they maintain certain character-defining features that make them distinctive. Bison and elk constitute an important element of these landscapes in Jackson Hole. However, the only officially recognized cultural landscape is Mormon Row in the Antelope Flats area of Grand Teton National Park, and it would not be impacted by actions taken in any of the alternatives.
- *Museum Objects* — No museum objects would be affected by alternatives being considered in this document.

Environmental Justice — No actions being considered in this environmental impact statement would disproportionately affect one or more minority groups compared to the general public. Hunting on the refuge and the elk reduction program in the park (as necessary in accordance with the legislatively mandated program) would be conducted solely as a wildlife management tool, not to accommodate public recreational opportunities, so no group would be disproportionately affected.

THE PHYSICAL ENVIRONMENT

The National Elk Refuge is 6 miles at its widest point and 10 miles from southwest to northeast; elevations range from 6,200 to 7,200 feet. The northern half of the refuge consists of steep rolling hills. The southern half is glacial washout material, with one resistant formation (Miller Butte) rising approximately 500 feet above the valley floor. The town of Jackson borders the refuge on the south, and the town of Kelly lies near its northern boundary. Lands to the south and west are mostly privately owned. East of the refuge are lands administered by Bridger-Teton National Forest, including the nearby Gros Ventre Wilderness.

Grand Teton National Park is 22.5 miles wide and 41 miles long from north to south. Elevations range from 6,420 feet on the valley floor to 13,766 feet (the summit of Grand Teton). The park is bordered to the northwest, west, and southwest by Targhee National Forest. On the south the park surrounds a wedge of private land and a small section of Bridger-Teton National Forest. The Teton Wilderness in the national forest borders the park to the northeast.

The John D. Rockefeller, Jr., Memorial Parkway extends for 82 miles from West Thumb in Yellowstone National Park to the south entrance of Grand Teton National Park. The management area between the two parks includes 7.5 miles of parkway and 23,778 acres.

The southern portion of Yellowstone National Park inside the Jackson elk herd unit ranges from about 6,900 feet in elevation near the park's south entrance to about 10,300 feet in the Red Mountains.

Ecologically, the National Elk Refuge, Grand Teton National Park, John D. Rockefeller, Jr., Memorial Parkway, and Yellowstone National Park are part of a larger area referred to as the greater Yellowstone ecosystem.

Most of the remainder of the Jackson elk herd unit is comprised of the Buffalo and Jackson ranger districts of Bridger-Teton National Forest. Elevation ranges from about 6,300 feet to nearly 12,200 feet at the headwaters of the Yellowstone River.

The Green River basin and the Red Desert range in elevation from less than 6,500 feet in the Red Desert to over 10,000 feet in the Pinedale and Big Piney ranger districts of Bridger-Teton National Forest. Topography is characterized by foothills, rivers, and lakes. The Red Desert is a relatively flat basin with no hydrologic outlet to major rivers.

SOILS

Over 20 different soil types are found on the National Elk Refuge (Young 1982). Soils at lower elevations are alluvial, generally sandy loam or loam, and are shallow and permeable. Soils at higher elevations are also loamy, with considerable areas of gravelly soils and cobblestone on south-facing slopes and ridges. Greyback gravelly loam, a deep, somewhat excessively drained soil, occurs in irrigated areas of the refuge. About 20% of the irrigated area includes areas that have a cobbly loam surface layer but that are otherwise similar to Greyback gravelly loam. Permeability is moderately rapid, and available water capacity is low. Roots penetrate to a depth of 60 inches or more. On 0% to 3% slopes the surface runoff is slow, and the erosion hazard is slight. On 3% to 6% slopes the surface runoff is medium, and the erosion hazard is moderate.

The Natural Resources Conservation Service has classified and mapped 44 soil types in Grand Teton National Park, ranging from shallow to deep loamy and stony soils to mostly deep, very cobbly and very stony soils. The soils of outwashes, tarns, terraces, and bottomlands include deep loamy and silty soils formed on loess or recent alluvium on gentle, rolling, and steep slopes to predominantly deep loamy and silty soils, which occur on moderately steep footslopes of the mountains.

Soils in the Green River basin and the Red Desert range from shallow to deep, well-drained alluvial soils (nearly level to steep terrain); to deep, well-drained gravelly or sandy soils in nearly level areas; to deep sand dunes; to deep well or somewhat poorly drained sandy and loamy soils in sloping floodplains and bottomlands.

CLIMATE

REGIONAL CONDITIONS

Jackson Hole is characterized by long, cold winters with deep snow accumulations, and short, cool summers. January is the coldest month with an average daily maximum temperature of 24°F and a minimum temperature of 1°F at low elevations. Temperature extremes vary from summer highs of 92°F to 98°F to winter lows of –40°F to –63°F.

Precipitation levels are relatively steady throughout the year, with a total average annual accumulation of 15.2 inches in Jackson Hole. Average monthly precipitation levels range between 1 and 2 inches, with May and December being wettest, and July and February driest. Jackson Hole averages 90 inches of snowfall per year, accounting for 60% of annual precipitation.

Snowfall varies considerably throughout the area of the Jackson elk herd unit. On the National Elk Refuge average snowfall ranges from 6 to 18 inches at the southern end up to 48 inches at the northern end. In Grand Teton National Park maximum snow depths range from 41–63 inches at low elevations (6,800 feet), to 82–98 inches at intermediate elevations (7,300–8,500 feet), and progressively deeper at higher elevations. Maximum snow depth is reached between March 15 and April 1 (Martner 1977). Elk tend to favor slopes with a southerly aspect during winter months because they can be snow free due to sunshine and southwest winds (Skovlin, Zager, and Johnson 2002).

One factor affecting forage availability for elk and bison is the amount of water contained within the snowpack, referred to as snow-water equivalents or how much water in inches is contained in the snowpack. Deep, light snow allows elk easier access to underlying vegetation than does a shallower, heavy snow. For modeling purposes, a snow-water equivalent of 6 inches was the threshold at which no forage would be available and elk would be unable to acquire sufficient food resources to survive on their own (Hobbs et al. 2003). Areas receiving 6+ inches of snow-water equivalents in one season would be unsuitable for elk winter range during that year. Temperature conditions that cause snow crusting would make forage less available at lower snow-water equivalent levels.

During an average winter, an estimated 51,000 acres in the Jackson elk herd unit area would likely be suitable as elk winter habitat (Wockner, pers. comm. 2002). Most of this acreage would be in the Gros Ventre River basin, with about 8,500 acres on the refuge, as well as in the Buffalo Valley area. Suitable habitat in years when snows were above average would decline to an estimated 20,000 acres, most of which would be in the Gros Ventre River basin and an estimated 2,600 acres on the refuge. In a severe winter suitable habitat would decline to an estimated 12,000 acres, with less than 700 acres on the refuge.

Climatic conditions during winter in the Green River basin and the Red Desert are much more moderate than in the Jackson Hole area. Average monthly temperatures during winter range from 20°F to 25°F, with average monthly minimum winter temperatures of –35°F to –42°F, and maximum temperatures from 52°F to 65°F (BLM 1996b). Average annual precipitation ranges from more than 16 inches in some foothill areas that could potentially be used by migrating elk, to about 7–10 inches throughout most of the Green River basin north of Rock Springs, to approximately 6–8 or fewer inches in the Red Desert (Knight 1994). In most winters snow accumulation in the Green River basin and the Red Desert would not substantially hinder forage access by elk.

A number of scientific studies indicate that in the past century the climate is becoming warmer and drier in northern Yellowstone National Park (Balling, Meyer, and Wells 1992a, 1992b). If this warming trend continues, it could have far-reaching effects on the flora and fauna of the greater Yellowstone ecosystem (Romme and Turner 1991).

WATER RESOURCES

NATIONAL ELK REFUGE

Surface Water

Surface hydrologic features on the National Elk Refuge include the Gros Ventre River, Flat Creek, Cache Creek, Nowlin Creek, and several other small creeks and springs. The Gros Ventre River flows westerly through the northern portion of the refuge, forming much of the northern boundary of the refuge. Flat Creek flows east to west and nearly bisects the refuge. In addition to natural watercourses, there are many miles of irrigation ditches. Three wells and an enclosed water storage reservoir are used by the town of Jackson.

The Gros Ventre River, which drains approximately 600 square miles of eastern Jackson Hole and the mountains farther east, is the largest watercourse on the refuge. The relatively wide river channel is heavily braided in areas where geologic materials are of low erosional resistance, as is the case on the refuge. The numerous gravel bars in the river channel have little or no vegetative cover as a result of annual flooding and erosion.

Flat Creek originates in the Gros Ventre Mountains east of the refuge and drains approximately 120 square miles. Flows vary seasonally due to runoff, input of irrigation water diverted from the Gros Ventre River, diversions by irrigators, and losses due to infiltration. The porous nature of refuge soils through which a section of Flat Creek flows causes high infiltration losses and results in a seasonally dry channel bed in this area.

Water from Cache Creek reaches the refuge via an underground diversion which surfaces into a cistern located near NER headquarters. Nowlin Creek is a small spring-fed tributary of Flat Creek. From the southeastern portion of the refuge, the creek flows westerly through four constructed impoundments to its confluence with Flat Creek. Smaller water features include Twin Creek and Holland Spring near the southeastern boundary, Romney and Peterson Springs in the western portion, and other miscellaneous springs throughout the refuge.

Surface water quality in Teton County is believed to be high but can be adversely affected by both point source pollution (e.g., a gasoline station along Flat Creek) and non-point source pollution (e.g., overland runoff of fecal matter from winter concentrations of livestock). Existing or future urban development has little or no potential of influencing the surface water quality on the refuge. Lower Cache Creek, however, flows through Jackson, and a diversion from this watercourse (the Cache Creek pipeline) enters the refuge and is used for irrigation. This section could be affected by urban runoff, potentially affecting downstream water quality (Jackson / Teton County 1994).

While there is no information about water quality in Cache Creek in the vicinity of the refuge, two ongoing studies on sections of the creek flowing through Jackson closer to its confluence with Flat Creek have determined that petroleum hydrocarbons (from vehicles) and sodium (probably from compounds used by local road departments for ice melting) are entering Flat Creek along with city stormwater, and a similar situation may be occurring on Cache Creek. Zinc, the only heavy metal found in stormwater samples, is also flowing into Flat Creek from the town, but its source is unknown (Norton, pers. comm., as cited in USFWS 1998). Hydrocarbon input might be reduced by using stormwater retention cisterns.

Another possible non-point source of pollution affecting refuge water quality, although not documented as a problem, is the large amount of fecal material produced by wintering elk and bison. The high concentration of waterfowl in the Nowlin marsh area is also suspected of contributing to decreased water quality in the lower section of Flat Creek on the refuge.

The Teton County Conservation District has conducted water quality sampling on several sites within the refuge (see Table 3-1). Nitrates are of particular concern. Although data from 1996 to 2002 showed nitrate levels consistently below EPA drinking water standards (10 ppm), detected levels in 1997 and in 2002 were higher than expected for typical western Wyoming waters (Stottlemeyer, pers. comm. 2003; Stottlemeyer et al. 2003). Activities such as irrigation, fertilization, and elk/bison fecal material could be contributing to these elevated nitrate concentrations, but further study is needed.

Map

Management Units and Surface Hydrology of the NER

TABLE 3-1: AVERAGE VALUES OF SELECTED WATER QUALITY PARAMETERS IN OR NEAR THE NATIONAL ELK REFUGE (1996–2002)

Monitoring Site	Flat Creek Control (near NER-BTNF boundary)	Flat Creek 1 (just above Fish Hatchery)	Nowlin Creek[1]	Flat Creek 2 (outside NER southwest boundary)[2]	Standard
Temperature (°F)	42.2 (8)	45.3 (10)	46.5 (4)	46.2 (11)	68
Dissolved Oxygen (mg/L)	11.2 (7)	10.5 (9)	9.51 (4)	9.8 (10)	
Turbidity (NTU)	0.0 (3)	1.1 (4)	1.4 (4)	26.8 (4)	
pH (units)	8.29 (8)	8.00 (10)	8.05 (4)	8.14 (11)	6.5–9.0
Nitrate as N (mg/L)	<0.1 (6)	0.14 (7)	<0.1 (5)	<0.1 (7)	10
April 2000 Sample					
Fecal Coliform (col./100ml)	3	53	55	60	200
E. coli (col./100ml)	1	45	49	29	126

NOTE: The number in parentheses is the number of samples tested.

1. The Nowlin Creek monitoring site is below the third pond, next to the barn and corral.

2. The second Flat Creek site is outside the refuge's southwest boundary, below the Dairy Queen, and subject to numerous outside influences (such as a major highway and gas station).

In 2002 the Teton County Conservation District implemented some source tracking of fecal coliforms. Results from DNA analysis showed that 34% of the coliforms come from rodents, 13% from bison, 13% from elk, 13% from unknown sources, 7% from canines, and 7% from birds.

Farming practices such as disking, seeding, sprinkler and drip irrigation, herbicide and fertilizer application, and crop harvesting may affect water quality and quantity. About 3,000 acres are also annually dragged using a blanket harrow to break up and help decompose deposited elk and bison fecal matter and aerate the soil.

The elk refuge has about 105 cubic feet per second (cfs) of adjudicated water rights for about 7,500 acres of irrigable land. The major water rights pertain to the Gros Ventre River (5.0 cfs), Flat Creek (74.4 cfs), Cache Creek (7.2 cfs), and Nowlin Creek (4.4 cfs). Other water rights include Twin Creek, Holland Spring, Romney Spring, Peterson Spring, and several other springs on refuge land. The refuge uses a negligible amount of the water that is diverted from the Gros Ventre River, getting most of the water used for irrigation from Flat, Cache, and Nowlin creeks.

Irrigation on the refuge is accomplished by sprinkler irrigation and through a flood irrigation system using contour and lateral ditches controlled by headgates. Of the water that is being diverted annually, only an estimated 5%–10% actually reaches its destination (Kremer, pers. comm., as cited in USFWS 1998). This loss is due in part to the porosity of refuge soils and to the state of disrepair of ditches and headgates. This, as well as annual precipitation, staffing, other refuge activities, and access to and availability of water, affect how many acres are irrigated on the refuge. In 1997 no fields were irrigated, and in 1993 a maximum of about 2,000 acres were irrigated; the annual average is about 960 acres.

Groundwater

Water-level contours indicate that groundwater flows from high areas southwest through the valley toward the Snake River. Data for the alluvial valley aquifer indicate excellent water quality, supporting utilization for drinking water supplies, recreation, and other commercial uses. Much of the aquifer exhibits high permeability and significant interconnection to the rivers and lakes, making it vulnerable to contamination from facilities, visitor use, and transportation corridors in the recharge areas.

Groundwater resources on the National Elk Refuge as a whole are considered of high quality and are not subject to septic-related pollution concerns except perhaps in the vicinity of Twin Creek Ranch and other inholdings. Residential and commercial development in Jackson and elsewhere in the county may cause local reductions in groundwater quality (Jackson / Teton County 1994). Although Jackson and surrounding areas use centralized wastewater treatment facilities, the perceived major threat to groundwater supplies elsewhere in the county is pollution from individual septic systems (Jackson / Teton County 1994).

GRAND TETON NATIONAL PARK

Surface Water

All surface and groundwater in the park drains into the Snake River, which originates in the highlands of the Teton Wilderness, flows north and west through Yellowstone National Park, south through John D. Rockefeller, Jr., Memorial Parkway, and into Jackson Lake. From Jackson Lake, the river flows east and then south for about 25 miles before leaving the park. The Buffalo Fork of the Snake River enters the park at Moran Junction. Eight major streams drain highlands in Bridger-Teton National Forest north and east of the park and flow into Jackson Lake or the Snake River within the park.

Approximately 1.98 million acre-feet of water (average daily flow is 2,740 cfs) flows out of the park annually via the Snake River. Annual flow of the Gros Ventre River is about 345,000 acre-feet (average daily flow is 475 cfs). These water resources contribute to vegetative diversity (including aquatic, wetland, and riparian plant communities), irrigation and forage production, groundwater discharge, the scenic viewshed, and they provide important habitats for various wildlife species.

Water diversion on the Gros Ventre River, although permitted by water law, does contribute to dewatering the river, which has negative consequences to invertebrates, fish, and other wildlife dependent on in-stream flow. As previously discussed, the National Elk Refuge uses a negligible amount of water from the Gros Ventre River for irrigation, with most coming from Flat, Cache, and Nowlin creeks. Dewatering due to use by private ranchers is beyond the scope of this document.

Surface waters within the park are of exceptionally high quality and are designated as class 1 (the highest of four water quality classifications) by the Wyoming Department of Environmental Quality (NPS 1998b).

Many of the lakes and streams in the greater Yellowstone ecosystem are very weakly buffered against pH lowering, which could be induced by acidic rain or snowmelt. Activities that can impact water quality and aquatic and riparian habitats include recreational activities, timber harvest, flood control, grazing by native and domestic ungulates, mining, and recreation facility development. A 2000 water quality study revealed high levels of fecal coliforms in irrigation diversions within the Elk Ranch area of the park (O'Ney, pers. comm. 2001). Through DNA source tracking, 32% of these coliforms came from bovine sources, 9% from bison, 9% from elk, 26% from unknown sources, and the rest from rodents, foxes, birds, horses, geese, and waterfowl.

Groundwater

Much of the eastern and central portions of the park (particularly areas covered by glacial outwash) have extensive groundwater resources (McGreevy and Gordon 1964; Cox 1974). Water tables vary from near the surface on floodplains to 30 to 60 feet below the surface on outwash flats and deeper in most upland areas. Numerous springs emerge along the park's east boundary, including several thermal springs near Kelly and East Gros Ventre Butte.

VISUAL RESOURCES

The quality of visual resources is an important part of the recreational experience (USFS 1982). The visual appearance of a landscape is often the first thing to which a viewer responds.

The National Elk Refuge and Grand Teton National Park, and the vast expanses of undeveloped national forest land surrounding the refuge and the park, offer spectacular scenic views of the Teton and Gros Ventre Mountain Ranges, the Sleeping Indian (Sheep Mountain), Jackson Peak, Cache Peak, Snow King, East Gros Ventre Butte, and the Gros Ventre hills in the northern portion of the refuge. The Gros Ventre River along the northern refuge boundary supports a cottonwood-dominated riparian zone along its drainage.

NATIONAL ELK REFUGE

The most prominent view of the refuge, which is seen by several million visitors annually as they drive to and from Jackson on U.S. 26/89, is the expansive Nowlin meadow area. During winter thousands of elk make the refuge an important visual and ecological resource for the region. Although bison are fed in areas that are not visible to the public, they can be viewed along the fence north of the Fish Hatchery and in the McBride area before Flat Creek Road is closed in December. As the herd grows, bison are more frequently seen in the southern sections of the refuge.

Features related to bison and elk management that may detract from the visual quality of the refuge include the following:

- an 8-foot fence, which runs for approximately 8 miles along the south and west boundaries of the refuge, to keep elk and bison from entering the town or migrating to the cattle ranches in Spring Gulch
- a powerline that parallels the highway north of Jackson for about 2 miles
- feed trucks and feed sheds
- a fish hatchery, Refuge Road, refuge housing, and private homes that are clearly visible from U.S. 26/87.

GRAND TETON NATIONAL PARK

The park viewshed is dominated by the spectacular Teton Range. Bison, elk, moose, bears, and a variety of smaller wildlife can all be spotted foraging near the roads that wind through the park.

Structures associated with private residences, park housing, and concessions are visible in some areas of the park. Some of these developments are part of the historical scene and may be cultural landscapes associated with historic districts listed on or eligible for listing on the National Register of Historic Places, while others, such as irrigation equipment near Triangle X Ranch, are more modern developments that intrude on the natural landscapes. Approximately 5,600 acres of previously cultivated park lands are unappealing to some people because the areas are dominated by smooth brome, musk thistle, and other nonnative invasive species.

HABITAT

NATIONAL ELK REFUGE

Plant Species of Special Concern

No plant species in Teton County have been federally listed or proposed for listing as threatened or endangered species. There are 13 Wyoming plant species of special concern on the National Elk Refuge (see Table 3-2).

TABLE 3-2: WYOMING PLANT SPECIES OF SPECIAL CONCERN — NATIONAL ELK REFUGE

Common Name	Scientific Name
Aster, rush	*Aster borealis*
Aster, Teton golden	*Heterotheca depressa*
Bladderpod, keeled	*Lesquerella carinata*
Bladderwort, flat-leaf	*Utricularia intermedia*
Bulrush, pygmy	*Scirpus rollandii*
Cottongrass, green-keeled	*Eriophorum viridicarination*
Milkvetch, railhead	*Astralus terminalis*
Muhly, marsh	*Muhlenbergia glomerata*
Sedge, Buxbaum's	*Carex buxbaumii*
Sedge, Canadian single-spike	*C. scirpoidea scripiformis*
Sedge, parry	*C. parryana*
Sedge, Sartwell's	*C. sartwellii*
Willow, hoary	*Salix candida*

Source: Fertig 1998

Plant Communities

Thirty-three plant community types have been classified on the National Elk Refuge, 23 of which are dominated by indigenous plants and 10 by cultivated species that were introduced or are being perpetuated due to agricultural activities. While some communities have adapted to natural conditions, most cultivated species are supported by continued flood irrigation.

For the purposes of this analysis, vegetative communities on the refuge may be classified into one of six general categories: wetlands (marshlands, wet meadows, and open water), native grasslands, sagebrush shrublands, riparian and aspen woodlands, conifer forests, and cultivated fields (see Table 3-3, and the "Plant Communities of the National Elk Refuge" map and the "Vegetation of the National Elk Refuge and Grand Teton National Park" map). Appendix C lists scientific names for plant species.

TABLE 3-3: NATIONAL ELK REFUGE — PLANT COMMUNITY TYPES

Habitat	Acres
Wetlands (2,676 total acres)	
Marshlands	630
Wet Meadows	1,720
Open Water	326
Native Grasslands	8,092
Sagebrush Shrublands	8,010
Riparian Aspen Woodlands	3,227
Conifer Forest	160
Cultivated Fields	2,400
Total	**24,565**

Wetlands (Marshlands, Wet Meadows, and Open Water)

The National Elk Refuge contains approximately 2,676 acres of wetlands, including marshlands, wet meadows, and open water. Wetlands function as a natural sponge that stores and recharges groundwater supplies. They moderate stream flow by releasing water to streams (especially important during droughts), and they reduce flood damage by slowing and storing floodwater. Wetland plants protect streambanks against erosion because the roots hold soil in place and the plants break up the flow of stream or river currents. Wetlands improve water quality by filtering sediment, pollutants, and excess nutrients from surface runoff. Wetlands are one of the most biologically productive ecosystems in the world. The nutrient-rich environment of wetlands provides food and habitat for a variety of wildlife.

Wetlands on the National Elk Refuge are some of the most diverse and important in the valley due to their water-regulating functions, visual qualities, and importance to wildlife, especially resident and migratory birds. Most wetland areas receive moderate to heavy use by elk but are generally considered to be in good condition. A few limited areas receive extremely heavy use, and they are considered to be in fair condition. Bison rarely used wetlands in the past but recently have begun to graze wet areas adjacent to the Poverty Flats feedground and wet meadows near the fish hatchery.

Map

Plant Communities of the National Elk Refuge

Map

Vegetation of Grand Teton National Park and the National Elk Refuge

Marshlands

Marshlands are low-lying and concave or occur on gentle slopes with seepage. They are inundated frequently or continually with water but are most often persistently saturated. Marshes are characterized by emergent soft-stemmed vegetation, such as sedges, rushes, cattails, and bulrushes, that is adapted to living in shallow water or in moisture saturated soils. Spring-inundated sites, which dry by fall, are also included in this category. Marshland communities presently occur on approximately 630 acres of the refuge and are considered to be in good condition (Cole, pers. comm. 2002). Good condition marshland habitats are dominated by bullrush, cattail, and sedge species. These stands develop to full stature each year dependent on water availability. In the marshland habitats, there is considerable residual material from previous years' herbaceous growth under the bases of growing plants, except in areas that have been previously burned. There is very little invasion from nonnative plant species in marshlands.

Wet Meadows

Wet meadow habitats currently occur on approximately 1,720 acres on the refuge and they are considered in good condition. Plant communities include shrubby cinquefoil and sedges, and typical grasses include foxtail barley, timothy, Kentucky bluegrass, tufted hairgrass, and common horsetail. Approximately 1,450 of the 1,720 acres contain willow plants less than 1.5 feet tall, indicating that mature willow stands have been converted to other plant communities because of decades of heavy elk browsing. Large numbers of elk on the refuge prevent these suppressed willow plants from growing out of the browse zone. Of importance, however, is the fact that the root systems of these willow plants remain and continue to attempt to regenerate by producing suckers.

Good condition wet meadow communities are dominated by nearly 100% cover of native sedge species and water-tolerant grasses. In some wet meadow habitats, shrubby cinquefoil is a major component of the cover. There is often very little residual cover due to heavy grazing by elk. The amount of residual cover in wet meadow communities varies from year to year depending on the depth of snow cover and grazing pressure. There is very little invasion from nonnative weed species. However, nonnative species, such as Kentucky bluegrass, fowl bluegrass, and clover (*Trifolium*) are present in wet meadow habitats.

Open Water

Open water accounts for 326 acres on the refuge and consists of stream and river channels and sites where standing water persists through most years, including pools and ponds.

Native Grasslands

Native grasslands occur where there is sufficient precipitation to grow grasses but not trees, or where drought, frequent fires, grazing by large mammals, or human disturbance has prevented trees or shrubs from becoming established. Native grasslands are the most important plant communities on the refuge because they provide winter forage for elk and bison, which are primarily grazers. Native grasslands, including some bluegrass, wheatgrass, and needlegrass species, cover approximately 8,092 acres. Except for localized areas, native grasslands are in good condition, especially in the northern part of the refuge (Cole, pers. comm. 2002).

On the south end of the refuge, there is little residual growth on bunchgrasses from the previous year of ungulate grazing during the grass's dormant season. This removal can result in increased production of some perennial bunchgrass plants, although standing dead plant material has been shown to be beneficial to plant health by some authors (Sauer 1978; Briske 1991).

The largest continuous segment of native grassland occurs in the central part of the refuge northeast of the Nowlin Creek marshlands, and northwest, west, and east of Flat Creek Road. This area is being invaded by crested wheatgrass, a nonnative wheatgrass that was once cultivated on the refuge. Crested wheatgrass currently covers approximately 650 acres. While this nonnative plant is very palatable to bison and elk in the spring, it has very little nutritional value to wildlife as winter forage. Its spread is a concern because the refuge is a winter range for ungulates. Although grassland condition in crested wheatgrass areas is good in terms of relative forage production, minimal erosion, and vigorous grass growth, the cover of native grass species has been reduced by 50% to 90% and replaced by crested wheatgrass in these areas (Cole, pers. comm. 2002). Therefore, the invasion of crested wheatgrass has the potential to degrade the condition of native grassland habitats on the refuge.

Cheatgrass has invaded an estimated 250 acres of native grassland on the refuge. This is an annual grass that is a prolific seed producer and cures out early in the summer, producing sharp pointed seeds that can injure the eyes and mouths of grazing animals. Cheatgrass may provide forage for bison and elk in the spring during green-up, but has little nutritional value as winter forage. It is considered a serious problem because the dry grass is highly flammable, and after a fire, cheatgrass spreads very quickly. In the past, cheatgrass was not considered a problem in Jackson Hole because the climate was too wet; the recent drought, however, has allowed cheatgrass to expand rapidly.

Most native grassland habitats are dominated by native perennial bunchgrass species with native woody species such as broom snakeweed and green rabbitbrush. There is little invasion by taprooted forbs between grass plants. Soil between grasses is not eroding on most native grasslands on the refuge. Additional plant species commonly found in native grasslands include rushes, smooth brome, brome snakeweed, yellow salsify, June grass, green rabbitbrush, fringed sage, and alfalfa. These communities, while heavily used by elk and bison, are considered to be in good condition. The Poverty Flats grasslands receive heavy use by elk, and Miller Butte receives moderate to heavy use. The grasslands on the northern end of the refuge receive much less use due to snow depth and hunting.

Sagebrush Shrublands

Sagebrush shrublands encompass approximately 8,010 acres and are scattered throughout the refuge, with the largest concentrations in the east-central and northeastern portions. Sagebrush shrublands are in good condition in the northern half of the refuge, with some small areas in fair condition in the McBride and Peterson management units (Cole, pers. comm. 2002). In the southern half of the refuge they are in poor condition due to over-browsing by bison and elk and mechanical damage by bison, elk, and feed equipment. Good condition sagebrush shrubland communities in a late stage of succession have a relatively high diversity and cover of herbaceous plants. It is possible that late seral sagebrush shrubland on the refuge is over-represented due to a history of fire suppression. Prior to Euro-American settlement, sagebrush habitats burned on average about every 25 years in this area (Houston 1973).

Sagebrush shrublands usually receive more precipitation (or grow on sites with more soil moisture) than grasslands but less than forested areas. Some areas have extremely tall sagebrush cover (in excess of 9 feet tall), and some areas have shorter and younger age classes. Communities are made up of shrubs and short trees and are fairly open, and there is a diversity of native perennial grasses and native forbs growing between sagebrush plants. Common species in this vegetative grouping include big and three-tipped sagebrush, bluegrass, snowberry, wild rose, and smooth brome. Douglas rabbitbrush is found throughout the refuge but occurs as a subdominant. Additional plant species commonly found in sagebrush shrubland communities on the refuge include needlegrass, wheatgrass, snakeweed, and rubber rabbitbrush.

Riparian and Aspen Woodlands

Riparian and aspen woodland communities occur on approximately 3,240 acres of the refuge. This habitat type has been declining in condition and acreage throughout refuge history. Riparian woodland habitat consists of approximately 300 acres of willow habitat and about 1,090 acres of cottonwood communities. An additional 1,450 acres of suppressed willow plants occur in what are now wet meadow communities, but were once willow habitat. Decades of winter browsing by elk have reduced these willows to remnant plants less than 18 inches high. Aspen woodland habitat consists of approximately 1,850 acres of aspen-dominated communities on hillsides usually some distance from water.

Riparian woodlands occur along the Gros Ventre River and Flat Creek. Aspen-dominated woodlands are scattered on the Gros Ventre hills throughout the northern part of the refuge and on the eastern edge of the refuge in the south, adjacent to the Gros Ventre Wilderness. Riparian and aspen woodlands are particularly important as wildlife habitat and have been affected by elk and bison browsing.

Riparian and aspen woodlands include stands of quaking aspen, narrowleaf cottonwood, and willows. Sedges, brome species, Douglas-fir, pinegrass, snowberry, rose species, bluegrasses, and big sagebrush in some areas may be codominants (those species that influence the kinds of other species that may exist in an ecological community). Engelmann spruce are scattered throughout the woodland stands but are subdominants. Additional plant species commonly found in riparian and aspen woodlands include species of rushes, Muhly, horsetail, yellow salsify, wheatgrass species, mountain timothy, needlegrass, serviceberry, chokecherry, buffaloberry, bearberry honeysuckle, and bitterbrush.

Dobkin, Singer, and Platts (2002) state that aspen, willow, and cottonwood stands on the National Elk Refuge have been degraded due to overbrowsing by ungulates; this is based on historical photographs, written records, and an understanding of the ecology of these communities. Dieni et al. (2000) and Smith, Cole, and Dobkin (2004b) also note the growing experimental evidence that ungulate browsing is the cause of declines in aspen and cottonwood communities. Studies of the effects of browsing on woody vegetation that began in 2000 on the refuge are continuing, and changes in woody plant communities will be monitored every five years.

Dobkin, Singer, and Platts (2002) also found that willow sites on the National Elk Refuge were "mostly poorly functioning or nonfunctioning ecologically." They concluded that although willow habitat is influenced by flooding, hydrologic conditions, ungulate use levels, fire frequencies, and precipitation patterns, the decline of willows on the refuge appears to be mostly related to heavy browsing (28%–55% removal of current annual growth). Decline of willows along Flat Creek in the southern portion of the refuge has exceeded 95%. Shrubby cinquefoil, a less palatable woody species, is abundant in this prior range of willow and has probably increased as willow declined. In contrast, willows in the north end of the National Elk Refuge are in fair to good condition. Many stands are moderately browsed, and some willow

Poor condition willow habitat.

Poor condition cottonwood habitat.

Poor condition aspen stand.

plants do not reach their full height potential. Growth of new willow stems out of the browse zone is sporadic, and there is some space between most willow clumps.

Elk browsing in cottonwood communities has removed understory, and cottonwood trees are not regenerating. Cottonwood stands close to the McBride feedground experience higher snag density and higher down woody debris cover. Cole did not find a difference in the number of woody plant species in stands closer to feedgrounds as compared to stands farther away (Cole 2002a, 2002b).

Many aspen stands are characterized by mature trees, with little if any aspen understory. Aspen recruitment is not taking place because heavy elk browsing on aspen suckers prevents most suckers from growing out of the browse zone. Many aspen stems are approximately 120 years old, which is approaching the maximum life span of 150 years. Most of these stands will eventually convert to sagebrush shrubland habitat, primarily in the form of snowberry / rose stands. A few aspen stands may convert to native grassland habitat, depending on their location and the understory condition. Although shrub and woodland stand health improve with increasing distance from feedgrounds, aspen woodland stands are in poor condition refugewide, as evidenced by low understory height measurements, regardless of the distance from feedgrounds (Smith, Cole, and Dobkin 2004a).

Cottonwood and aspen saplings grow inside exclosures (fenced areas) on the upper section of Flat Creek, indicating these trees can replace themselves if ungulates are totally excluded. Aspen stands in the northern hills of the refuge appear to be declining slowly, but some aspen communities escape browsing, and stand replacement is occurring periodically.

Conifer Forest

Conifer forests on the refuge cover 160 acres and consist of Douglas-fir, lodgepole pine, junipers, wheatgrasses, and other plant species. These forests are in good to fair condition in terms of the conifers' ability to regenerate, but subdominant species that are much more palatable, such as serviceberry, are in poor condition. Conifer forests occur mostly on the extreme eastern edge of the refuge in the north and the south on hillsides adjacent to Bridger-Teton National Forest and on the northern slopes of the Gros Ventre hills.

Additional plant species commonly found in conifer forests on the refuge include snowberry, June grass, bluegrass species, buffaloberry, mountain boxwood, and serviceberry.

Elk use the conifer forests on the refuge and the adjacent forestland for cover and shelter from winter storms and also graze on palatable understory shrubs and grasses. Bison rarely use conifer stands.

Cultivated Fields

Ten plant community types are found in cultivated fields (approximately 2,400 acres) in the south and central part of the refuge. Current plant species include intermediate wheatgrass, Russian wild rye, Kentucky bluegrass, subirrigated bluegrass, smooth brome, and alfalfa. Smooth brome is the most common; it provides moderate-quality standing forage but is undesirable because of its inability to remain erect in heavy snow. Smooth brome also requires irrigation in drought years and may spread to suitable sites in other cultivated fields and native grassland habitats. Cultivated grasslands are planted specifically to augment native forage that is available for elk in the winter and are used extensively by elk and bison. Cultivated species are chosen based on their palatability, persistence, ability to compete with weeds, low probability that they will invade native grasslands, and their ability to stand up after a heavy snowfall. Experiments with other plant species are continuing in an effort to find more productive crops. From 2,000 to 2,400 acres are cultivated in any particular year, depending on how much land is left fallow or whether some fields need to be treated for weeds.

Of the 33 plant communities on the refuge, 25 occur in the six irrigation project areas that would be affected by changes in the irrigation system. Native grasslands, cultivated grasslands, and invasive crested wheatgrass are the only vegetative classes present in the six project areas (see Table 3-4). Some community types have changed since being mapped in 1986; for example, several fields in the Chambers area that were once vegetated in wheatgrass and smooth brome are now virtual monocultures of crested wheatgrass.

Irrigation Systems

Most cultivated fields on the refuge are flood irrigated using the ditch system created by original homesteaders but with some recent modifications. Current flood irrigation involves diverting water from Flat, Cache, and Nowlin creeks, or other

TABLE 3-4: GRASSES FOUND IN THE SIX IRRIGATION PROJECT AREAS ON THE NATIONAL ELK REFUGE

Irrigation Project Area / Grasses	Acres
Chambers	
Wheatgrass / bluegrass (*Elymus* spp. / *Poa* spp.)	60
Kentucky bluegrass *(Poa pratensis)*	75
Intermediate wheatgrass (*Elytrigia intermedia*)	195
Subtotal	330
Ben Goe	
Subirrigated bluegrass (*Poa* spp.)	59
Smooth brome / alfalfa (*Bromus inermis* / *Medicago sativa*)	382
Crested wheatgrass (*Agropyron cristatum*)	14
Subtotal	455
Petersen	
Smooth brome (*Bromus inermis*)	145
Great Basin wild rye *(Elymus cinereus*)	21
Intermediate wheatgrass (*Elytrigia intermedia*)	17
Kentucky bluegrass (*Poa pratensis*)	6
Wheatgrass / needlegrass / bluegrass (*Elymus* spp. / *Stipa* spp. / *Poa* spp.)	59
Subtotal	248
McBride	
Wheatgrass / mixed grasses	268
Smooth brome / alfalfa	132
Intermediate wheatgrass (*Elytrigia intermedia*)	98
Russian wild rye (*Elymus junceus*)	30
Subtotal	528
Nowlin	
Intermediate wheatgrass (*Elytrigia intermedia*)	54
Subirrigated bluegrass (*Poa* spp.)	54
Wheatgrass / mixed grasses (*Elymus* spp. /	267
Kentucky bluegrass (*Poa pratensis*)	32
Subtotal	407
Headquarters	
Subirrigated bluegrass (*Poa* spp.)	24
Crested wheatgrass (*Agropyron cristatum*)	53
Smooth brome / mixed grasses (*Bromus inermis* /	101
Creeping foxtail *(Alopecurus arundinaceus)*	42
Intermediate wheatgrass (*Elytrigia intermedia*)	30
Subtotal	250
Total	**2,218**

watercourses or sources, conveying this water through open irrigation ditches, and then directing water onto fields by using permanent water control structures or temporary check dams. A total of 60 acres of cultivated fields are irrigated using a side-roll sprinkler irrigation system.

Currently, the National Elk Refuge flood irrigates approximately 665 to 2,000 acres/year, with a 10-year average of 930 acres per year. Sprinkler irrigation could increase to 260 acres under existing authority. Cultivated fields that are not irrigated vary from an estimated 500 to 2,400 acres per year (with a 10-year average of about 1,400 acres/year).

Forage production in any given year depends on crop species planted, the number of years since seeding occurred, infestation by insect herbivores such as grasshoppers, fertilizer application, precipitation, amount of water available for irrigation, and number of staff available for irrigation activities. The time of year that precipitation occurs is also important. Rain in the spring and early summer is more beneficial than later in the year. Water available for irrigation depends more on snowpack than growing season precipitation.

Experimental Exclosures

Experimental exclosures are designed to measure the growth of forage when large herbivores are excluded. Exclosures on the refuge currently enclose about 20 acres of woody habitat.

Forage Production outside Exclosures

Forage production on the refuge varies annually, depending on precipitation, temperature, insects, fields allowed to lie fallow, and other factors. Estimates of both herbaceous and total forage production between 1987 and 2002 are presented in Table 3-5. The refuge produces an estimated average of 22,195 tons of forage annually, about 18,049 tons (81%) of which is herbaceous forage. This estimate is most meaningful for elk management in terms of usable and preferred forage. However, not all herbaceous forage produced on the refuge is available to or used by wintering elk. Factors such as topography, location, snow accumulation and condition, species preference and palatability, growth form of vegetation, hunting pressure, and other factors work in concert to influence forage availability and elk use.

Forage Production Monitoring Data

Forage production has been monitored on the refuge for the past 17 years, with data collected annually along 51 transects throughout the refuge to determine production rates associated with community types (see Table 3-5). From this information, refuge-wide production estimates have been extrapolated. There is a degree of variability in terms of site-specific range condition and forage production, and the generalized data are not well suited to predict forage production outside transect locations.

TABLE 3-5: TOTAL FORAGE AND HERBACEOUS FORAGE PRODUCTION ESTIMATES FOR THE ENTIRE NATIONAL ELK REFUGE, 1987–2002

	Herbaceous Forage		Total Forage		Cultivated Fields	
Year	Lbs	Tons	Lbs	Tons	Lbs	Tons
1987	29,642,000	14,821	35,898,000	17,949	NA	NA
1988	29,582,000	14,791	33,616,000	16,808	NA	NA
1989	41,650,000	20,825	50,736,000	25,368	6,362,000	3,181
1990	40,038,000	20,019	49,658,000	24,829	6,622,000	3,311
1991	40,904,000	20,452	47,712,000	23,856	8,140,000	4,070
1992	38,576,000	19,288	45,782,000	22,891	6,306,000	3,153
1993	55,168,000	27,584	74,192,000	37,096	11,232,000	5,616
1994	37,592,000	18,796	45,660,000	22,830	3,756,000	1,878
1995	45,461,000	22,730	53,782,000	26,891	7,892,000	3,946
1996	42,378,000	21,189	53,782,000	23,295	5,930,000	2,965
1997	46,282,000	23,141	51,048,000	25,929	7,250,000	3,625
1998	39,294,000	19,647	44,730,000	22,365	6,900,000	3,450
1999	31,700,000	15,850	39,254,000	19,627	5,640,000	2,820
2000	22,598,000	11,299	33,580,000	16,790	1,852,000	926
2001	18,118,000	9,059	28,994,000	14,497	1,968,000	984
2002	18,606,000	9,303	28,184,000	14,092	3,242,000	1,621
Average	36,099,312	18,049	44,788,000	22,195	5,193,250	2,597

SOURCE: NER staff.

NONNATIVE INVASIVE PLANT SPECIES

Many nonnative plant infestations on the refuge are a direct result of abandoned livestock feeding areas and corrals, old homesites, and roadbeds. At least 19 species of invasive nonnative plants are present (see Table 3-6). Such species reduce the diversity and number of native plants and modify habitats (i.e., replacing a grass community with a forb community). Studies in Montana indicate that bison and deer reduced their use of a particular habitat by 70%–82% when it was invaded by leafy spurge. Elk forage in bunchgrass sites was decreased by 50%–90% after a spotted knapweed invasion (Teton County Weed and Pest 2002). Nonnative invasive plants also fail to protect and hold soil because they generally have a shallow root system, leading to increased erosion and sedimentation in streams. This in turn affects water quality and decreases fish production.

The refuge and park both use biological, mechanical, and chemical means to control invasive plants. Nonnative plants on the refuge have not substantially affected forage conditions, but spotted knap-

TABLE 3-6: NONNATIVE INVASIVE WEED SPECIES ON THE NATIONAL ELK REFUGE

Weed Species	Minimum Acreage	Maximum Acreage
Bindweed (*Convolvulus arvensis*)	< 0.1 acre	
Black henbane (*Hyoscyanus niger*)	<0.2 acre	
Bull thistle (*Cirsium vulgare*)	<0.5 acre	10 acres
Canada thistle (*Cirsium arvense*)	0.1 acre	15 acres
Common tansy (*Tanacetum vulgare*)	<0.5 acre	
Dalmation toadflax (*Linaria dalmatica*)	0.2 acre	2 acres
Diffuse knapweed (*Centaurent diffusa*)	< 1 acre	
Hound's tongue (*Cynoglossum officinale*)	0.2 acre	2 acres
Marsh sow thistle (*Sonchus arvense*)	5 acres	20 acres
Musk thistle (*Carduus nutans*)	35 acres	125 acres
Oxeye daisy (*Leucanthemum vulgare*)	< 0.1 acre	
Perennial pepperweed (*Lepidium latifolium*)	0.1 acre	
Russian knapweed (*Centaurea repens*)	< 1 acre	
Scentless chamomile (*Matricaria perforata*)	<0.2 acre	
Scotch thistle (*Onopordum acanthium*)	0.1 acre	1 acre
Spotted knapweed (*Centaurea maculosa*)	25 acres	120 acres
Whitetop (*Cardaria draba*)	5 acres	30 acres
Wooly mullein (*Verbascum thapsus*)	1 acre	15 acres
Yellow toadflax (*Linaria vulgaris*)	< 1 acre	

weed and musk thistle invasions in the park are considered serious (Haynes, pers. comm. 2002).

GRAND TETON NATIONAL PARK

PLANTS SPECIES OF SPECIAL CONCERN

There are 52 Wyoming plant species of special concern in Grand Teton National Park (see Table 3-7).

PLANT COMMUNITIES

More than 1,000 vascular plant species (Shaw 1992b) and over 200 fungi species (McKnight 1980) occur in Grand Teton National Park or nearby Teton County. Nonnative species include 117 that have migrated within the last 75–100 years or remain from previous cultivation (Shaw 1992a).

From 1986 to 1988 the vegetation of the national park and John D. Rockefeller, Jr., Memorial Parkway was classified and mapped. Sixty-three plant community types were identified, which are classified under nine general categories: wetlands (marshlands, wet meadows, and open water), native grasslands, sagebrush shrublands, riparian and aspen woodlands, conifer forest, agricultural lands, human development, bare rock and krummholz, and tundra (see Table 3-8). Elk occur in most habitat types throughout the national park, except for alpine peaks. Bison use native grassland communities, agricultural lands, and sagebrush shrubland habitats, which occur on the southeastern side of the park from the border with the National Elk Refuge, north to the south side of Emma Matilda Lake, and to certain riparian corridors within that area. Although elk and bison use coniferous forests for cover, conifer forests are more affected by management actions than by ungulate grazing. Because the bare rock and krummholz and the tundra communities will not be affected by bison and elk management, they are not discussed further.

The park primarily provides spring, summer, and fall habitat for elk and bison. However, some elk and bison winter in the areas of the Snake River bottomlands in the southern end of the park, Spread Creek, and some portions of Buffalo Valley (elk only), which are south/southeast and east of Moran, respectively.

TABLE 3-7: WYOMING PLANT SPECIES OF SPECIAL CONCERN — GRAND TETON NATIONAL PARK

Common Name	Scientific Name	Common Name	Scientific Name
Agoseris, pink	*Agoseris lackschewitzii*	Peony, Brown's	*Paeonia brownii*
Alkali-grass, Fernald	*Torreyochloa pallida fernaldii*	Pepperwort	*Marsilea vestita oligospora*
Aster, Teton golden	*Heterotheca depressa*	Pod-fern	*Aspidotis densa*
Beargrass, western	*Xerophyllum tenax*	Pondweed, blunt-leaf	*Potamogeton obtusifolius*
Bladderpod, keeled	*Lesquerella fremontii*	Pondweed, flatstem	*P. zosteriformis*
Bladderpod, Payson's	*L. paysonii*	Pondweed, Fries	*P. friesii*
Bladderwort, lesser	*Utricularia minor*	Porterella, western	*Porterella carnosula*
Broomrape, flat-top	*Orobanche corymbosa corymbosa*	Rush, thread	*Juncus filiformis*
Broomrape, Louisiana	*O. ludoviciana arenosa*	Rush, Tweedy's	*J. tweedyi*
Bur-reed, small	*Sparganium minimum*	Sedge, bristly-stalk	*Carex leptalea*
Butterweed, sweet-marsh	*Senecio hydrophiloides*	Sedge, Cusick	*C. cusickii*
Clubmoss, fir	*Huperzia selago*	Sedge, lesser panicled	*C. diandra*
Cotton-grass, green keeled	*Eriophorum viridicarinatum*	Sedge, little prickly	*C. echinata*
Cotton-grass, slender	*E. gracile*	Sedge, Sartwell's	*C. sartwellii*
Draba, boreal	*Draba borealis*	Sedge, smooth-stemmed	*C. laeviculmis*
Duckweed, pale	*Lemna valdiviana*	Spikerush, delicate	*Eleocharis bella*
Fern, Aleutian maidenhair	*Adiantum pedatum*	Stitchwort, crimped	*Stellaria crispa*
Fern, American alpine lady	*Athyrium distentifolium americanum*	Sundew, English	*Drosera anglica*
Hawkweed, scouler	*Hieracium scouleri*	Triteleia, large flower	*Triteleia grandiflora*
Helleborine, giant	*Epipactis gigantea*	Twayblade, broad-leaved	*Listera convallarioides*
Horsetail, water	*Equisetum fluviatile*	Violet, western rough-leaved	*Viola pedatifida*
Kelloggia, milk	*Kelloggia galioides*	Water-flaxseed, common	*Spirodela polyrhiza*
Milkvetch, railhead	*Astragalus terminalis*	Whitlow-grass, thick-leaved	*Draba crassa*
Milkvetch, Shultz's	*A. shultziorum*	Willow, Mackenzie's	*Salix eriocephala mackenzieana*
Naiad, southern	*Najas guadalupensis*	Woodfern, spreading	*Dryopteris expansa*
Oak-fern	*Gymnocarpium dryopteris*	Wood-rush, smooth	*Luzula glabrata hitchcockii*

SOURCE: Fertig and Beauvais 1999.

Wetlands (Marshlands, Wet Meadows, and Open Water)

Marshlands

Marshland communities, which occur on approximately 16,970 acres in Grand Teton National Park, are considered to be in good condition (Haynes, pers. comm. 2003). As on the refuge, these stands develop to full stature each year depending on water availability. There is considerable residual material in marshlands from previous years' herbaceous growth under the bases of growing plants. There is very little invasion from nonnative invasive species in marshlands.

Wet Meadows

Grand Teton National Park contains approximately 13,390 acres of wet meadow habitats. Wet meadow communities are considered to be in good condition except for localized areas. 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 percent bare ground in some wet meadow habitats. Kentucky bluegrass, a nonnative grass species, and oxeye daisy, a nonnative invasive species, 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 yet thrive and expand. Heavy grazing pressure on the edges of these meadows appears to be allowing both these nonnative invasive species to outcompete native grasses and to expand their range (Haynes, pers. comm. 2003).

TABLE 3-8: PLANT COMMUNITY TYPES — GRAND TETON NATIONAL PARK AND JOHN D. ROCKEFELLER, JR., MEMORIAL PARKWAY

Habitat	Acres
Wetlands (65,852 total acres)	
Marshlands	16,970
Wet Meadows	13,390
Open Water	35,492
Native Grasslands	8,093
Sagebrush Shrublands	56,843
Riparian and Aspen Woodlands	22,324
Conifer Forest	123,093
Agricultural Lands	5,610
Human Development	597
Bare Rock and Krummholz	58,640
Tundra	5,635
Total	333,295

Open Water

Open water consists of stream and river channels and sites where standing water persists through most years, including pools, ponds, and lakes.

Native Grasslands

Native grassland communities cover approximately 8,093 acres in Grand Teton National Park. This category includes dry grassland meadows, high-elevation meadows, moist grass meadows, and forb meadows. A variety of grasses, sedges, and rushes are abundant. Depending on moisture and elevation, vegetation may be dense to open, and low to moderately saturated. Elk and bison graze this plant community extensively. Native grasslands are generally in good condition except for localized areas. Good condition native grassland habitats are dominated by native perennial bunchgrass species, with native woody species such as broom snakeweed and green rabbitbrush also present in some areas at low densities. Soil between grasses is not eroding on most native grasslands in the park, although heavily grazed areas have up to four times as much bare ground as areas that are lightly grazed.

Sagebrush Shrublands

Sagebrush shrubland habitat in Grand Teton National Park covers approximately 56,843 acres, and a high amount is in an advanced stage of succession. Sagebrush dominates the porous, cobbly flatland of the valley floor. Moist sagebrush sites occur on moist benches, floodplains, and hillsides with north and east exposure. For the most part, mountain big sagebrush dominates these sites, with three-tip sagebrush dominant in some areas. Silver sagebrush and shrubby cinquefoil are possible co-dominants in moist sites. Dry sagebrush sites occur on convex or even topography and generally south-facing exposed hillsides. Native perennial grasses and forbs grow at fairly high density (depending on moisture) in the spaces between sagebrush plants. Bare ground is often evident, particularly in dry sites. Elk and bison graze this plant community extensively.

Under natural conditions, sagebrush shrubland habitat would burn on average about every 25 years in this area (Houston 1973), and the fire-return interval is currently much lower than this. Late succession sagebrush communities are generally in good condition, with a diversity of herbaceous vegetation in the understories.

Riparian and Aspen Woodlands

Riparian and aspen woodlands occur on approximately 22,324 acres in Grand Teton National Park. Bands of cottonwood, willow, aspen, and spruce line the meandering courses of the Snake River and its tributaries. Willows grow on floodplains and along streamsides. Tall willow species, usually more than 60 inches at maturity, are characteristic of dominant shrubs in the floodplain. Alder and birch may be present in some areas; undergrowth is varied. Aspen stands occur in upland areas. Other deciduous shrubs such as willow, serviceberry, chokecherry, rose, and gooseberry species in cottonwood stands also show a decline in height, density, and regeneration.

Elk browse on the aspen, willow, and cottonwood communities, especially in the spring. Bison may shelter in the cool river bottoms. Most willow habitats in the park appear to be in good to excellent condition. However, cottonwood communities along the Snake River are being encroached on by conifers due to a change in the flood regime since the Jackson Dam was built in 1910. Ungulate browsing and trampling is also impacting some cottonwood stands. In addition, the combined effects of fire suppression, ungulate browsing, and climate change are threatening to limit the ability of aspen stands to regenerate in Grand Teton National Park (McCloskey and Sexton 2002).

Additional plant species commonly found in riparian and aspen woodlands include species of rushes, Muhly, horsetail, yellow salsify, wheatgrass species, mountain timothy, needlegrass, serviceberry, chokecherry, buffaloberry, bearberry honeysuckle, and bitterbrush.

Conifer Forest

Conifer forest habitat covers approximately 123,093 acres in the national park. Elk use the forest for cover and shelter, particularly from storms. The mountain slopes and the lower prominences rising from the floor of the valley are covered largely by conifers — limber, lodgepole, and whitebark pine, Engelmann spruce, subalpine fir, and Douglas-fir. The slopes of morainal ridges, and such mountain-peak remnants as Blacktail Butte, are also forested. The condition of this habitat type is considered to be good.

Agricultural Lands

Agricultural lands include 5,610 acres of historically cultivated lands that occur in the Elk Ranch area in the northern part of the national park and the Kelly hayfields, Mormon Row, and Hunter-Talbot areas in the southern part of the park. Most of the fields were planted at the turn of the 20th century to produce pasture and hay for cattle in the winter months. An estimated 1,100 acres of acreage continue to be irrigated in the Elk Ranch area, and planted species include smooth brome, bluegrass, timothy, and occasionally alfalfa. The fields no longer cultivated are dominated by nonnative invasive plants such as the common dandelion, Canada thistle, and musk thistle.

Human Development

Development sites include areas where the natural environment has been modified as a result of human activities, typically to the point of eliminating most native vegetation. The 597 acres of development sites include lodges, subdivisions, airports, home sites, farm and ranch buildings, and paved highways.

Nonnative Invasive Plants

As described for the National Elk Refuge, many nonnative plant infestations in Grand Teton National Park are a direct result of abandoned human developments. Much of the valley floor is now under NPS management, but these lands have not yet been restored. Twenty species of nonnative invasive plants are present, 12 of which are the same as on the National Elk Refuge (black henbane, common tansy, Canada thistle, Dalmation toadflax, diffuse knapweed, hound's tongue, musk thistle, oxeye daisy, perennial pepperweed, Russian knapweed, spotted knapweed, and yellow toadflax). Other species include Dyer's woad, leafy spurge, orange hawkweed, St. John's wort, sulfur cinquefoil, tamarisk, whitetop, and yellow hawkweed.

BRIDGER-TETON NATIONAL FOREST

Information on the vegetation of Bridger-Teton National Forest was obtained primarily from the *Teton Division Landscape Scale Assessment* (USFS 2003b), which encompassed the Buffalo Ranger District and much of the Jackson Ranger District (i.e., most of the Jackson elk herd unit); and the *Oil and Gas Leasing Final Environmental Impact Statement* (USFS 2002), which relied on vegetation data compiled for the forest plan as baseline information for the vegetation inventory. Vegetation and habitat type inventories were conducted during 1990, during which aspen stands and old-growth conifer stands were verified. Additional information was incorporated to supplement the discussion, including a general floristic survey conducted by the University of Wyoming in 1990, which emphasized threatened, endangered, and sensitive plants (Hartman et al. 1991).

Bridger-Teton National Forest covers approximately 3,392,200 acres within five Wyoming counties: Lincoln, Sublette, Teton, Park, and Fremont. The Jackson elk herd unit occupies approximately 935,000 acres of the national forest (Brimeyer, pers. comm. 2003).

Two areas of Bridger-Teton National Forest are of interest to this bison and elk management planning process.

1. The national forest portions within the Jackson elk herd unit roughly correspond to the Jackson and Buffalo ranger districts. These lands are primarily used by elk for summer range, but they also provide winter range, especially in the Gros Ventre River basin, the Buffalo Valley area, and east of the National Elk Refuge. A small part of national forest lands (e.g., along the eastern edges of the refuge and park) are used by bison during other seasons.
2. The area between the southeastern extremity of the herd unit and the Green River basin and the portions of the national forest along the northeastern and western sides of the Green River basin, which falls within the Pinedale and Big Piney ranger districts. It would primarily be used as transitional range and possibly as winter range by migrating elk under Alternatives 2 and 3 (if such migrations actually occurred). Currently, a few elk from the Jackson elk herd unit use these and other national forest lands (unpublished information, NER files).

Vegetation in these two areas reflects both natural and human disturbances. Fire, timber harvest, browsing by livestock and native ungulates, and other natural and human-caused disturbances have played major roles in shaping existing conditions. The forest is dominated by a spruce / fir conifer woodland and by sagebrush shrublands; aspen habitat is a major component in some areas.

PLANT SPECIES OF SPECIAL CONCERN

Based on records from the Wyoming Natural Diversity Database, the upper Green River basin and its surrounding mountains support some of the greatest concentrations of rare and endemic plants in Bridger-Teton National Forest and the greater Yellowstone ecosystem (Hartman 1995; Hartman et al. 1991).

The Wyoming Natural Diversity Database lists 34 plant species of special concern in the analysis area of Bridger-Teton National Forest. Of these, 2 are high priority and 18 are medium priority (see Table 3-9).

PLANT COMMUNITIES

For the purposes of this analysis, vegetative communities on the national forest are classified into one of four general categories: wetlands (marshlands and wet meadows), sagebrush shrublands and native grasslands, riparian and aspen woodlands, and conifer forests.

Wetlands

Wet meadow habitat in the Jackson and Buffalo ranger districts occurs primarily in valley-bottom riparian corridors and in some openings in conifer forests. The condition varies from good to fair or poor (USFS 2003a). Most wet meadow habitats likely do not receive heavy use by elk, but heavy use does occur in some areas, especially near state feedgrounds. Livestock grazing can also be heavy

TABLE 3-9: PLANT SPECIES OF SPECIAL CONCERN — BRIDGER-TETON NATIONAL FOREST

Common Name	Scientific Name	Common Name	Scientific Name
Bladderpod, keeled	*Lesquerella carinata* var. *carinata*	Pondweed, flatleaf	*Potamogeton robbinsii*
Braya, Arctic	*Braya glabella*	Pondweed, Fries	*P. amplifolius*
Bulrush, pygmy	*Scripus rollandii*	Pondweed, strict-leaved	*P. strictifolius*
Campion, creeping	*Silene repens* var. *australe.*	Reed-grass, dense pine	*Carex luzulina* var. *atropurpurea*
Cinquefoil, one-flower	*Potentilla uniflora*	Rockbrake, fragile	*Cryptogramma stelleri*
Draba, Payson's	*Draba paysonii*	Saw-wort, Weber's	*Saussurea weberi*
Goldenweed, narrowleaf	*Haplopappus macronema* var. *linearis*	Sedge, black and purple	*Carex luzulina* var. *atropurpurea*
Lousewort, mountain	*Pedicularis pulchella*	Stitchwort, thread-branched	*Minuartia filiorum*
Milkvetch, Payson's[1]	*Astragalus paysonii*	Tansymustard, Wyoming[2]	*Descurainia torulosa*
Milkvetch, railhead	*Astragalus terminalis*	Violet, kidney-leaf white	*Viola renifolia* var. *brainerdii*

1. Unless noted, all plant species of special concern in this table are medium priority, which are state or regional endemics listed as rare or disjunct (separated species with moderate threats or poor protection).
2. A high-priority species, which means it is most vulnerable to extinction and listing under the Endangered Species Act.

in some areas, although the amount of overgrazing that occurred in riparian bottoms before 1986 (Boyce 1989) has been reduced. Small wet meadows in conifer forest openings are typically in good ecological condition (USFS 2003a).

Sagebrush Shrubland and Native Grasslands

Sagebrush shrubland and grassland habitats are the most common nonforest habitats in the national forest. The condition of these habitats is probably similar in the Big Piney and Pinedale ranger districts, with a lower than natural amount of grassland habitat, reduced production in sagebrush habitats, and degraded aspen stands (Stroud, pers. comm. 2004). The foothill transition area between the lower elevation open sagebrush country and higher elevation conifer forests is discussed below under "Conifer Forest."

Southern slope mosaics can provide important winter ranges for elk, mule deer, and bighorn sheep. The southern slope mosaic commonly occurs on relatively steep, southerly facing slopes and includes a variety of plant communities.

Riparian and Aspen Woodlands

Approximately 43,900 acres of aspen occur in the Jackson and Buffalo ranger districts, excluding the Teton Wilderness, which has not been inventoried. An estimated 90%–95% of these aspen stands are in a mature state, characterized by mostly even-age trees in declining health that exhibit little regeneration and heavy encroachment by conifer trees and sagebrush (USFS 2002). An estimated 13,500 acres of aspen habitat exists in the upper Green River grazing allotments in the Pinedale Ranger District, or about 8% of the project area (USFS 2004b). Most of the aspen stands in the Big Piney Ranger District are also in a mature condition (Stroud, pers. comm. 2004).

The U.S. Forest Service considers the level of browsing by elk and moose in many aspen stands to be intense due to high numbers of elk, especially near feedgrounds (Krebill 1972a, as cited by USFS 2003a; BLM 1981). Current browsing in the Gros Ventre River drainage would eventually eliminate aspen habitat on elk winter range (Krebill 1972a; Bartos, Brown, and Booth 1994). Livestock browsing is also contributing to the decline in aspen habitat. In the Pinedale and Big Piney ranger districts, over-browsing of aspen by elk does not appear to be a major contributing factor to the decline of aspen habitat, except near feedgrounds (Stroud, pers. comm. 2004).

Much of the aspen habitat in the Jackson and Buffalo ranger districts continues to be in a degraded, declining condition. While no formal research on wolves and recovery of woody vegetation has been conducted in Bridger-Teton National Forest, wolves appear to be changing elk distribution and reducing the amount of time elk spend in aspen stands, thereby allowing a greater proportion of aspen suckers to survive (Kilpatrick, pers. comm. 2004).

Willow habitat primarily occurs in valley bottoms in association with streams. In some cases, willow communities are restricted to thin strips, while in other cases they can span entire valley bottoms. Many willow communities are dominated by Booth's willows and wolf willows.

Willow habitat has been severely impacted by elk and moose near state feedgrounds in the Gros Ventre River drainage, and elk, moose, and livestock browsing is preventing recruitment and recolonization of willow in some places (USFS 2003a; Kilpatrick, pers. comm. 2004). In areas where moose populations are high, all willow stands within a drainage may be adversely impacted by wintering moose (Yorgason 1963; Anderson 2002; Singer and Zeigenfuss 2003).

There is little direct information on browsing of willows in the Pinedale and Big Piney ranger districts, but it is likely that ungulate browsing and impacts are similar to what occurs in other locations in the national forest.

Many of the cottonwood stands along the Gros Ventre River are in a condition of decline and not regenerating due in part to heavy browsing by elk and moose, as well as livestock (USFS 2003a). This is especially true near state feedgrounds.

Conifer Forest

Conifers dominate approximately half of the Jackson and Buffalo ranger districts in the Jackson elk herd unit. This amount could likely increase as the area burned in 1988 converts from shrubs and herbs to conifer communities (USFS 2003b).

The subalpine fir forest is the dominant forest type in mid to lower elevations and an important component of elk summer and fall range (USFS 2003b). Lodgepole pine forests are another major component of the forestland in the Teton division. It is a major seral species occurring at elevations below 9,400 feet and is primarily associated with the spruce-fir forest types. Moist Douglas-fir forests typically occur on north slopes, and seral species may include lodgepole pine, aspen, limber pine, and Douglas-fir. Douglas-fir dominates mature stands, and understories in the Teton division are either Rocky Mountain maple, pine reedgrass, white spirea, or blue huckleberry.

Cool dry Douglas-fir forests typically occur on south- and southwest-facing ridges in the lower portion of the Gros Ventre River drainage and on lower slopes north of the lower Buffalo River. This forest type is important to wintering elk because it has a relatively high amount of forage, including grasses and shrubs (USFS 2003b). Although cool dry Douglas-fir forests occupy a minimal amount of the Teton division of Bridger-Teton National Forest, they are highly relevant to this planning process because this would be the predominant forest type to be treated in restoring and enhancing winter range in the Gros Ventre River drainage and Buffalo Valley area.

Currently, cool dry Douglas-fir forests are in degraded condition due to high densities of young trees. Under natural conditions these forests would be comprised of widely spaced, large mature trees that allow periodic ground fires to maintain an open, savanna-like setting with a productive herbaceous community. Fire suppression has allowed seedlings and young trees to survive, and openings between 200–300 year-old trees have become dominated by 40–60 year-old trees. This has caused a major reduction in the production of underlying herbaceous communities.

Conifer trees also dominate a large portion of the Pinedale and Big Piney ranger districts where elk from the Jackson elk herd unit might migrate and winter (USFS 2004b). The area between the south end of the Jackson elk herd unit and the Green River basin has many of the same conifer forest types as found within the Jackson elk herd unit.

At the lower elevations along the western, northern, and northeastern edges of the Green River basin, a variety of habitats occur. Moving up in elevation from the Wyoming and mountain big sagebrush habitats in the Pinedale Resource Management Area, the landscape transitions into a mosaic of mountain big sagebrush-bitterbrush, grassland, aspen, Douglas-fir, lodgepole pine, and riparian areas (Knight 1994). This zone would be a key area for elk transitional range and migrations under Alternatives 2 and 3. Ridges, such as Pinyon Ridge (northeast of Bacon Ridge and north of the Green River Lakes area), are currently important transitional and winter range, and the Wyoming Game and Fish Department is working with the U.S. Forest Service to enhance habitat conditions in this and other winter and transitional habitat (Stroud, pers. comm. 2004).

The interruption of the fire cycle has likely resulted in the expansion of Douglas-fir forests onto sites within the foothill transition zone that may have been kept treeless by periodic fires (Knight 1994). Douglas-fir and lodgepole pine are also beginning to dominate aspen stands due to fire suppression. Furthermore, herbaceous production in understories has probably declined substantially or has been eliminated due to the canopy cover of encroaching trees (Stroud, pers. comm. 2004).

Nonnative Invasive Plants

Eighteen species of nonnative invasive plants are present in the analysis area, and their densities and spread are believed to be increasing each year. Of these, 16 are the same as those on the National Elk Refuge or in the national park (Canada thistle, common tansy, diffuse knapweed, bindweed, black henbane, hound's tongue, leafy spurge, musk thistle, oxeye daisy, perennial pepperweed, marsh sowthistle, scentless chamomile, spotted knapweed, sulfur cinquefoil, white-top, and yellow toadflax). Other species include common burdock and yellow star thistle.

Vehicles and equipment are often the main source of nonnative invasive weed seeds and plant materials. Once established, wind, water, and native fauna can aid in the spread and establishment of nonnative invasive plants.

SOUTHERN YELLOWSTONE NATIONAL PARK

The northern limit of the Jackson elk herd unit's summer range extends to the southern shore of Yellowstone Lake. About 80% of Yellowstone National Park is forested (Knight 1994), and forests cover an even larger percentage of the landscape occupied by the Yellowstone National Park elk herd segment. This part of Yellowstone National Park is dominated by lodgepole pine forests, vast portions of which are in an early to mid stage of succession since the fires in 1988 (Knight 1994).

OTHER FEDERAL AND STATE LANDS

BLM Parcels in Jackson Hole

The Bureau of Land Management administers about 2,085 acres of land along the Snake River through Jackson Hole in 27 separate parcels. Specific habitat types include riparian forest, riparian shrubland, riparian grassland, upland habitats, palustrine habitat, and riverine habitat (BLM 2003b). While all of these types may occur to some degree along the river reaches under BLM jurisdiction, the principal cover type is riparian forest, which is dominated by a narrow-leaf cottonwood riparian complex.

In 1990 the U.S. Fish and Wildlife Service predicted a declining trend in the condition of the cottonwood forests along the Snake River corridor due to a lack of over-bank flooding necessary for recruitment of new trees. Habitat-type mapping by the U. S. Army Corps of Engineers supported this prediction. The declining trend in vegetation condition is likely to continue with the operation and maintenance of the flood-control levees and the dam at Jackson Lake.

Wetland habitat types along the river include palustrine emergent, palustrine scrub, and aquatic bed (USACE 1994, 1999). The palustrine scrub wetlands are found primarily on stable gravel bars and dikes and are dominated by willow and mountain alder. Sedges, cattails, and bulrush are the primary species in palustrine emergent wetlands. The dominant species in aquatic bed wetlands depend on the underlying soil. Aquatic beds along shorelines tend to support watercress. Pondweed is common in streams and ponds with silt bottoms; ballhead waterleaf occurs in rocky substrates (USACE 1994, 1999).

Over 30 rare plant species tracked through the use of the Wyoming Natural Diversity Database occur in the vicinity of the Snake River corridor (USACE 1994, 1999). None of these species is federally listed or proposed as threatened or endangered species. Meadow pussytoes, Trelease's milkvetch, Cedar Rim thistle, large-fruited bladderpod, Beaver Rim phlox, and tufted twinpod are considered extremely rare (5 or fewer occurrences) to rare (21 to 100 occurrences) in Wyoming or regionally.

Disturbances resulting from maintenance and levee construction along the Snake River leave large areas open for colonization by nonnative invasive plant species. Species include spotted knapweed, Dalmatian toadflax, houndstongue, Canada thistle, and musk thistle.

The Bureau of Land Management has proposed to transfer its parcels along the Snake River to other public agencies (2003b). If it cannot transfer the lands, management agreements would be pursued to allow other agencies or entities to manage public uses on the parcels. Any sale, exchange, or transfer of public land would include, where appropriate, the use of conservation easements to prohibit development and preserve scenic values, wildlife habitat, and open space.

FEDERAL AND STATE LANDS IN THE GREEN RIVER BASIN AND THE RED DESERT

Sagebrush Shrubland

Sagebrush habitat types comprise the majority of the Pinedale and Green River resource management areas, including all landownerships. Wyoming big sagebrush is the most prevalent plant community type in the Green River basin, but at roughly 7,400 feet in elevation mountain big sagebrush becomes increasingly abundant (Knight 1994; Stroud, pers. comm. 2004).

The degraded condition of shrubland habitats continues to be a major factor affecting large ungulate populations throughout Wyoming, including the Green River basin and the Red Desert (WGFD 1995; Madson 2001; Stroud, pers. comm. 2004), although conditions may have improved somewhat since 1996 on livestock grazing allotments in the Green River Resource Management Area (BLM 1996b; Weymand, pers. comm. 2004). In particular, the disrupted fire cycle in sagebrush shrubland habitats has resulted in aging shrubs and reduced browse quality (WGFD 1995; Shroud, pers. comm. 2004). Although elk graze primarily on grass during winter where available, shrubs are increasingly important to elk during deeper snow conditions.

The introduction and spread of nonnative plant species, and grazing by large mammals (including livestock and feral horses), as well as other factors, annually reduce the amount of herbaceous vegetation. The Steamboat elk herd also affects the amount of grass available during winter months since they are year-round residents, but affected areas are relatively small.

Desert Shrubland

Desert shrub communities comprise more than 10% of the Pinedale and Green River resource management areas, second only to sagebrush shrubland habitat (BLM 1986, 1996b). The most prominent desert shrubland communities include saltbush desert shrubland, desert grasslands, mixed desert shrubland, greasewood, and saltgrass meadows associated with playas (Knight 1994). Saltbush desert shrublands, which are characterized by sparse plant cover and Gardner saltbush, may be the most arid plant community in the area. Mixed desert shrubland has a larger diversity of shrub species. Greasewood and saltgrass meadows occur on the fringes of playas, desert lakes, ponds, rivers, and creeks (BLM 1996b).

Riparian and Aspen Woodlands

Riparian habitat in the Green River basin and the Red Desert comprises only about 0.5% of the landscape (BLM 1986). Aspen habitat is the favored habitat of mule deer and elk, and ungulate and livestock browsing has hindered the restoration of willow and other woody riparian vegetation in some places (Weymand, pers. comm. 2004). Cottonwood communities also exist along some watercourses, but many are on private lands (BLM 1986), such as along the Green River.

The BLM riparian cover classification includes greasewood and sagebrush along stream courses. Riparian communities occur along the area's rivers, perennial and intermittent streams, and around hundreds of springs, seeps, sloughs, and reservoirs (BLM 1996b). Some streams naturally support willows, aspen, and cottonwood trees, while others do not.

Plant communities in meadows are primarily comprised of grasses and forbs (BLM 1986). On drier meadows and at the fringe of wet meadows, more mesic grass species may occur, along with shrubby invaders such as silver sagebrush and shrubby cinquefoil.

PRIVATE LANDS

TETON COUNTY

Teton County considers 28 nonnative invasive weed species a threat for various reasons; as previously mentioned, there are no threatened or endangered species.

Jackson Hole Area

Private land in Jackson Hole and Buffalo Valley consists of approximately 67,500 acres of developed and undeveloped land (Jackson Hole Land Trust 2003). Of this total, nearly 40,000 acres are in agricultural production. Private agricultural lands include base operations for ranchers that seasonally graze their livestock on surrounding Forest Service and BLM lands. An estimated 23,500 acres of private land have been developed in the Jackson Hole area. Conversion to residential and commercial development has more adverse impacts to elk, bison, and other wildlife than conversion to agricultural production (Segerstrom, pers. comm. 2003). Housing developments, even at relatively low densities, substantially impair habitat effectiveness for elk and bison. Habitat has been permanently lost within the developed areas of Jackson, Wilson, Teton Village, Kelly, Hoback Junction, and surrounding residential areas. Habitat effectiveness has been significantly reduced in other areas, including areas of Buffalo Valley, where housing densities do not qualify as residential developments.

Even though vegetation has been altered on undeveloped private lands, some private lands on the valley bottom continue to support willow, cottonwood, and native meadow habitat, although the condition of remaining willow and cottonwood habitat is relatively poor. Common plants that occur in cottonwood stands and other woody riparian communities on private lands are similar to those listed above for BLM parcels along the Snake River in Jackson Hole. Some private lands in the Jackson Hole area also contain grassland, sagebrush, aspen, and coniferous habitats. Habitat condition varies widely.

Many houses have been built on footslopes adjoining agricultural lands, such as aspen stands, sagebrush slopes, and low elevation conifer forests on private lands. Large acreages of aspen habitat (e.g., on the west slopes of East and West Gros Ventre buttes) and long stretches of cottonwood habitat along the Snake River now contain moderately high to high densities of houses (e.g., an average of more than one house per 15 acres). Levees along the river prevent flooding of these areas, which hinders stand regeneration. In general, the condition of cottonwood habitat along the Snake River is declining on private lands for many of the same reasons it is in declining on lands under the jurisdiction of the Bureau of Land Management. On some private lands, browsing pressure by elk in cottonwood forests is heavy to severe (Segerstrom, pers. comm. 2003)

As of 2005, 19,756 acres of willow, aspen, cottonwood, meadow, and sagebrush habitats and agricultural lands are protected on some large parcels of private land due to conservation easements. These include several stands of aspen on the west slopes of East and West Gros Ventre buttes, a large contiguous block of cottonwood habitat in the South Park area of Jackson Hole, and several large willow stands in Buffalo Valley.

Some remaining undeveloped private land (approximately 26,000 acres) continues to provide important staging and migration corridors for elk, and some could potentially provide winter range for elk and possibly bison. An estimated 15,000 acres could be developed in the next 5–10 years (Jackson Hole Land Trust 2003), in which case elk movements would be further restricted.

Green River Basin and the Red Desert

Private lands in the Green River basin and the Red Desert contain the same habitats described for these areas under “Other Federal and State Lands.” Larger parcels containing sagebrush, riparian, and other native habitats are commonly grazed by livestock. A large proportion of private lands fall within historic riparian zones, and on average, these lands are more productive than federal or state lands.

THE JACKSON ELK HERD

Elk, as well as bison, play an important ecological role in Jackson Hole and are recognized as vital elements of the native biota that interact dynamically with their environment.

There is some indication that grazing by elk and bison can increase the productivity and stability of grassland systems, enhancing the nutrient content of grazed plants (Frank and McNaughton 1993; Singer 1995; Wallace 1996). They may contribute to new plant growth by distributing seeds, fertilizing by recycling nutrients through their waste products, and breaking up soil surfaces with their hooves and wallows (bison only). As prey and carrion, elk and bison provide sustenance to a host of carnivores and scavengers.

HISTORY OF ELK IN JACKSON HOLE

When Europeans arrived in North America, an estimated 10 million elk roamed the forests and plains from the east to the west coast (Seton 1953) and were categorized into six subspecies. By the early 1900s the elk herds of North America had dwindled to less than 50,000, most being concentrated in the greater Yellowstone ecosystem (Seton 1953).

Historically, elk probably persisted in Wyoming's mountain ranges longer and at higher numbers than in any other state (Murie 1951). The extensive mountain ranges surrounding Jackson Hole and Yellowstone National Park were among areas noted for particularly abundant elk (O'Gara and Dundas 2002).

The first homesteaders settled Jackson Hole in 1884. Prior to that time, trappers' journals are the only documentation of large elk herds in the valley. Some people believe that most of the Jackson elk herd wintered in the valley, despite its often severe winters. Others, based on a number of historical accounts, believe that some if not most of the Jackson elk herd did not winter in Jackson Hole (Murie 1951; Allred 1950; Cromley 2000). Early settlers told of seeing long lines of elk migrating into areas where snow depths were lower and forage more accessible, both west into the Teton Valley, and also east into the Green River Valley and continuing south to the Green River basin and continuing south to the Red Desert, as shown on the "Possible Historical Elk Migration" map (Cromley 2000; Anderson 1958). The following discussion describes the basis for this belief in more detail.

Historical reports indicate that the herd summered in the higher country surrounding Jackson Hole and as far north as southern Yellowstone National Park, and at the onset of winter moved into Idaho, the Star Valley, the upper Gros Ventre Basin, and South Park in southern Jackson Hole (Murie 1951). Some continued through the Gros Ventre Basin into the Green River area and others through and beyond the Hoback Basin. In severe winters elk were reported in parts of the Red Desert in southern Wyoming.

Although there are many anecdotal reports about migration, there is no direct evidence to substantiate these reports to say unquestionably that elk in Jackson Hole migrated to the Green River Basin or the Red Desert (Cole 1969; Boyce 1989). Cromley (2000) summarized a large number of historical accounts and biological information that indicates migration did occur, and several biologists who spent many years studying elk in the Jackson Hole area came to similar conclusions (Allred 1950; Murie 1951; Anderson 1958; Smith, pers. comm. 2004). What is known is that by the late 1800s (Saylor 1970) human settlement and conversion of winter range to use by domestic livestock shortened migration routes and caused elk to remain in the climatically severe and less populated Jackson Hole. Competition between starving elk and livestock for haystacks, combined with excessive hunting, trapping of elk for shipments to the east, and poaching (including "tusk" hunting) also influenced elk numbers and movements (Craighead 1952; Cromley 2000; Nelson 1994; Blair 1987).

A number of severe winters in the late 1800s and early 1900s meant greater depredation losses and high mortality among the Jackson elk herd. In 1909 the people of Jackson appealed to the government for help and the Wyoming legislature appropriated money for elk feed. Additional

Map

Possible Historical Elk Migration

Map

Jackson Elk Herd Unit and Fall Migration Routes money was sent in 1911 by the U.S. Congress, which also sent biologist E. A. Preble to investigate the situation. His subsequent report (Preble 1911) was instrumental in the establishment of the National Elk Refuge in 1912. The first winter census in Jackson was conducted in 1912, and showed about 20,000 elk residing in Jackson Hole and the Hoback River drainage.

The National Elk Refuge

Elk are the primary wildlife species occupying the National Elk Refuge and their conservation is the reason the refuge was established. The creation of Yellowstone National Park in 1872 and the National Elk Refuge in 1912 were crucial in terms of protecting elk and their winter ranges in the greater Jackson Hole area. Supplemental elk feeding was initiated to mitigate the loss of natural winter range and impacts to livestock operations. By the 1930s the feeding program had successfully stabilized the elk population. The creation of Grand Teton National Park in 1929, as well as its expansion in 1950, consolidated and protected elk summer ranges within this area.

The initiation of feeding in any given year depends on elk numbers, the timing of migration, winter temperatures, snow depths, and the accessibility of standing forage. Non-feeding years have occurred irregularly and infrequently. Since the refuge was established in 1912, there have been nine years when no feeding was provided. The last such winter was in 1980–81.

Elk were fed hay during at least a portion of most winters from 1912 to 1975. In 1975, after several years of testing, a switch was made to alfalfa pellets (Smith and Robbins 1984). Biologists evaluate several factors to determine whether feeding is needed, and if so, when it should begin and end. Since 1912, the period of supplemental feeding has ranged from "no feeding" to a maximum of 147 days. Elk currently are fed an average of 70 days annually.

Hunting

Hunting is the primary management tool used to control the size of the Jackson elk herd and its main source of mortality. The first hunting season on the National Elk Refuge occurred in 1943, but hunting did not become an annual event until 1955. When Grand Teton National Park was expanded in 1950, fears of a burgeoning elk population resulted in the addition of language in the legislation to allow an elk reduction program in the park east of the Snake River when it was considered necessary for management of the elk herd.

From 1998 to 2002 the annual harvest of elk ranged from about 2,300 to 3,300, and approximately 16% of the pre-hunt Jackson elk herd population was removed annually. The program, along with the elk reduction program in Grand Teton National Park, takes place from mid-October to mid-December and is used as a tool to bring total elk numbers as close as possible to the WGFD herd objective of 11,029. In addition to WGFD harvests in Bridger-Teton National Forest and non-federal lands, hunting occurs on the refuge and the elk reduction program in the park each fall. Over the last 20 years harvests in the park have contributed about 25% to the total harvest, and those on the refuge, about 10%. The remaining 65% of the harvest takes place mainly in the national forest.

Elk Numbers in Jackson Hole and on the Refuge

The most recent modeled population estimate for the Jackson elk herd was 13,356 for 2003–4 (WGFD 2004a). From 1989–90 through 2003–4, population levels averaged 16,352 animals (range 13,200–18,825), 32.5% above the objective of 11,029, and 13,694 animals from 1999–2000 through 2003–4 (range 13,200–14,277), or 19.5% above objective.

In 2003 the portion of the herd that wintered on refuge lands numbered approximately 7,000. The 20-year average has been about 8,000, although numbers have ranged from 5,000 to 11,000. The remainder of the herd winters in Grand Teton National Park, on state feedgrounds, and on native winter range. Native winter range outside the refuge and the park includes Bridger-Teton National Forest for the most part, plus a small percentage of private lands. Estimates of elk numbers on the native winter range vary from 3,600 to 9,400. The average number of elk on native winter range from 1989 through 2002 has been about 5,500 according to estimates based on WGFD computer modeling. Herd objectives for the native winter range are 2,900 to 5,200, or 3,700 on average. The park receives more snow and supports relatively fewer wintering elk than the refuge. An average of 536 elk, and a range of 206 to 1,299 elk, have wintered in the park (WGFD post-hunt classification counts for 1989–2003). Herd objectives are that the average number of elk in the park would be at about 356, and numbers would range between 137 and 857. Factors influencing winter elk distribution include greater snow depths and smaller amounts of available forage in the park (Farnes, Heydon, and Hansen 1999; Hobbs et al. 2003), the attraction of elk to irrigated and cultivated lands on the refuge, and many years of supplemental feeding on the refuge and WGFD feedgrounds (B. Smith 2001).

HABITAT AND FORAGE

Elk are versatile generalists (Houston 1982) and use a mixture of habitat types in all seasons. Having evolved as an ecotone species in cold, temperate climates, elk retain features adaptive to both wooded and plains environments; they prefer open areas (Geist 1982) but also use dense coniferous forests for shelter (Clark and Stromberg 1987).

Cole (1969) found that elk distribution in winter was related to elevation, suitable forage, distribution of other elk, human disturbance, and weather variables. Elk can cope with a wide variety of deep and crusted snow conditions (Barmore 1980).

Classified as intermediate feeders, elk are less selective than either browsers or grazers (Baker and Hobbs 1987). Forage availability during winter (Jenkins and Wright 1988), and differences in nutritive value during other seasons are important influences on food choices (Merrill 1994; Cook 2002). In winter elk primarily use open grassland, preferring cured grasses when these are available, but using browse species as well (Murie 1951); they may also be found in forests where they prefer shrubs (Cole 1969). In spring they use relatively open grassland with some timber, and in late summer and fall they use a variety of grassland and forest types.

Grass comprises most of the diet in all seasons. Cole's (1969) examination of the Jackson herd found that forage proportions within the average yearlong diet were 51% grass and grasslike plants (sedge and rush species), 26% forbs, and 23% shrubs. Shrub species included willow, narrowleaf cottonwood, aspen, and silverberry.

Supplemental feeding bolsters the nutritional status of 68% to 91% of the Jackson herd in most winters and staves off weight loss. Elk on native winter range may lose from 5%–15% of body mass in an average winter (Wisdom and Cook 2000) and 25% or more in severe winters. Various mechanisms, such as reduced activity levels and metabolic rates, insulating winter fur, behavioral adaptations, and catabolism of body fat, allow ungulates to cope with the energetic costs of winter and avoid death when supplemental feeding is not available (Mautz 1978).

Bailey (1999) collected empirical data on fat reserves and overwinter body condition in elk from the Jackson herd over two winters (1996–1997 and 1997–1998) and found that both free-ranging and supplementally fed elk were in good to excellent condition. He noted that he did not collect animals that appeared unhealthy, hence the study may not have been entirely representative of the condition of the Jackson elk herd.

DISTRIBUTION AND MOVEMENTS

Adaptable foragers with a mixed diet, elk frequent a variety of habitats and move about seasonally. While they make short movements in the fall after the first frosts occur, they generally remain on summer range until heavier snow covers forage, stimulating migrations to lower wintering areas. A few elk forgo migration and winter on wind-swept, more exposed parts of their summer range.

Elk use extensive spring, summer, and fall ranges to the north, west, and east in Grand Teton National Park, Bridger-Teton National Forest (including the Teton Wilderness), and as far away as southern Yellowstone National Park (Smith and Robbins 1994). According to Boyce (1989), these ranges provide nearly unlimited supplies of forage. Smith (2000) later estimated that summer distribution of the Jackson herd is approximately

30% Grand Teton National Park, 30% Gros Ventre, 25% Yellowstone National Park, and 15% Teton Wilderness.

Approximately half of the elk wintering on the refuge summer in Grand Teton National Park (Smith and Robbins 1994); in some years about 200 elk summer on the refuge. Fall migrations begin in October or November and end in mid-December (Smith and Robbins 1994). Elk move southward from their summer ranges toward the National Elk Refuge, channeled in some places by steep terrain and lakes (see the "Jackson Elk Herd Unit and Fall Migration Routes" map).

Some Jackson elk move hardly at all because their ranges are nearer the refuge, while others cover up to 60 miles (100 km) between summer and winter ranges, probably farther than other elk herds in North America (Boyce 1989; Murie 1951; Preble 1911). Migrations may occur over periods of a few days to several weeks.

Winter range includes areas north of Ditch Creek, the Spread Creek-Uhl Hill areas, the Buffalo River valley, the Gros Ventre River and Snake River floodplains, as well as public lands east of the National Elk Refuge and Grand Teton National Park. Variation in annual snowfall affects elk distribution; for example, when snowfall is particularly heavy, a larger portion of the herd can be found wintering on the refuge and utilizing WGFD feedgrounds, three of which are distributed along the Gros Ventre River drainage. Conversely, in years of little snowfall, fewer elk migrate as far south as the refuge and more of them remain on native winter range.

Spring migrations to calving and summer range begin when the snow recedes and new vegetation appears, usually in April and May (Cole 1969). Hazing has been used to encourage animals inclined to remain on the refuge to move northward in the spring. Several studies have been conducted to determine seasonal distribution of elk that wintered on the National Elk Refuge. These studies showed elk were dividable into four herd segments: the Grand Teton (48%), the Yellowstone (28%), the Teton Wilderness (12%), and the Gros Ventre River drainage (12%) (Smith and Robbins 1994).

Although many elk migrate to "traditional" summer ranges, some individuals are more exploratory and move beyond areas known to them or their mothers (Murie 1951). Radiotelemetry studies provide evidence of long-distance movements as far away as the Wind River drainage and Targhee Creek, 15 miles from West Yellowstone, Montana. Movement patterns of elk in the Gravelly-Snowcrest Mountains of southwestern Montana revealed interchange between that population and adjacent Montana, Idaho, and Wyoming elk populations, including Grand Teton National Park and the National Elk Refuge (Hamlin and Ross 2002).

BEHAVIOR AND SOCIAL INTERACTIONS

An elk avoids predators by "rapid and sustained flight while trying to disorient pursuers by various tricks and, thereby to lose itself in vast expanses" (Geist 2002). For calves to survive, they must be large at birth and grow quickly (Geist 1986, 1991, 2002). Elk feed on grasslands and in open areas, but they also rely on wooded areas for cover and hiding newborns (Geist 2002).

Males and females are ecologically separated throughout much of the year due to differing adaptive strategies: females favor security, while large, quickly growing young males focus on food intake to maximize body size and antler growth (Geist 1982, 2002). Although considered herd animals, group size fluctuates widely (Murie 1951). In the spring elk cows may be alone, or in small groups of two or three when calves are born. When calves can move well, larger groups of cows, calves, and young bulls form. During the summer cows, calves, and young bulls are found in mixed-sex groups varying in size from 20 to 300 elk or more. At the same time, older bulls are often alone, but some may also form small groups. During the fall rut, cows and calves are found in smaller groups that can be managed by one mature bull. Younger bulls sometimes band together, but some remain near the herd and are able to join groups later in the season. Elk again form large groups during the fall migration and may maintain large herds throughout the winter, depending on the weather and forage availability. Elk may also be found as individuals, in small groups, or in larger herds at any time of the year (Murie 1951).

Elk respond to hunting by moving from open to closed areas or by remaining in areas closed to hunting if they are there when hunting begins in the fall (Martinka 1969).

BREEDING, CALVING, AND AGE AND SEX CLASSES

The breeding season or rut begins in September and lasts through October. The rut changes elk social structure. Older bulls join the cows and younger animals and groups become smaller. During the rut a breeding bull attempts to sequester and maintain control of a herd of 6 to 30 or more individuals, including 10 to 15 cows (Murie 1951). While bulls as young as two or three may be sexually mature, they are unable to compete successfully against older, heavier males. The largest bulls in prime condition (usually six to eight years old) are the most successful at gathering harems and fending off challengers.

Based on winter counts from 1989 through 2003, there have been an average of 20 mature bulls per 100 cows. More recent ratios indicate a higher number of bulls (23–24).

For bulls, fending off rivals with chases and sparring matches, and herding females and keeping them in a guardable harem, are energetically demanding activities. Bulls also expend energy and time with attention-getting activities such as urine spraying, wallowing, bugling, and vegetation horning (thrashing vegetation with antlers). Mature bulls eat less than usual during this period, entering winter with their surplus body fat depleted. Unlike bulls, cows continue to eat normally during the rut and maintain good body condition (Murie 1951; Geist 1982). When the mating season ends, harems disband, cows rejoin their herd, and bulls form bachelor groups.

Most calving takes place during the transition between winter and summer ranges (see the “Elk Calving Areas” map). After a gestation period of about 8.5 months, elk give birth in late May to early June. Although twins occur occasionally, most cows give birth to a single calf (Murie 1951).

Cow elk use various habitats for calving but seem to prefer sagebrush habitats on gentle slopes near the forest edge and close to water (Johnson 1951; Anderson 1958). They seek solitude when calving and habitat that will provide cover to hide newborns from predators. High mortality occurs in the first two months of life because calves have not yet acquired the stamina and speed to escape coyotes, bears, or other predators. An estimated 70% of all calves do not survive beyond eight or nine months (USFWS 2002a). While elk often return year after year to the same calving areas, snow levels can alter this behavior.

During the last 20 years, calf-to-cow ratios on the refuge have averaged 24.2 calves per 100 cows. Average calf-to-cow ratios were slightly lower than this during the last 10 years, with an average of 20.7 calves per 100 cows observed during midwinter counts.

Calf-to-cow ratios in the Jackson elk herd decreased over the last 15 years from 22 per 100 cows to 16 per 100 cows, but rose in 2004 to 28 per 100 cows. Reasons for the decline are unknown, but may have included increased harvest of female elk, predation, and/or drought (WGFD “2002 Annual Big Game Herd Unit Report”). Winter supplemental feeding has been found to increase survival of Jackson elk calves (<1 year old) (Smith and Anderson 1998).

OTHER FACTORS INFLUENCING ELK NUMBERS, DISTRIBUTION, AND HEALTH

AMOUNT, QUALITY, AND AVAILABILITY OF WINTER AND TRANSITIONAL RANGE

Seasonal availability of suitable habitat profoundly affects the distribution and health of many species, including elk. As winter approaches, ungulates migrate to lower elevations and gradually alter their diets, adding plant species of decreasing palatability and nutritional quality as preferred foods become less available (Leopold 1933; Halfpenny and Ozanne 1989).

The amount, quality, and availability of winter and transitional range depend on temperature and precipitation, both of which are highly variable. Halfpenny and Ozanne (1989) cited temperature, snow depth, snow density, duration of winter, and lateness of spring as critical factors affecting moose survival in Grand Teton National Park.

Map

Elk Calving Areas

According to Halfpenny and Ozanne (1989), ungulates generally start migrating when snow depth reaches mid-calf height on the leg of a mature animal, or 2–3 inches snow water equivalent (Farnes, Heydon, and Hansen 1999). During 1968–81 northern range bison and elk in Yellowstone National Park generally foraged in areas with less than 6 inches snow water equivalent, although a snow depth of 1–2 inches snow water equivalent was enough to initiate migration by at least some of the herd (Farnes, Heydon, and Hansen 1999). For the purposes of this planning process, a snow water equivalent measure of 6 inches was used as the threshold between usable and unusable winter grazing habitat (Hobbs et al. 2003). Snow crusting events that reduce access to forage would lower this threshold.

EXISTING AND POTENTIAL DISEASES

Diseases for both elk and bison are described in this section since they tend to be similar in both species. Diseases could affect the numbers, distribution, and health of the elk and bison herds in several ways, as summarized below. Infectious diseases in the Jackson elk herd are also of concern because of potential transmission to domestic animals (mainly cattle and horses).

Tests indicate that three documented viral microparasites — bovine viral diarrhea, parainfluenza virus-3, and bovine respiratory syncytial virus — are present in Jackson Hole elk and bison. Infrequent clinical disease consistent with bovine viral diarrhea has been observed in Jackson bison, but its cause is unknown. The contribution of these viruses, if any, to mortality related to respiratory bacteria or septic conditions like hemorrhagic septicemia is unknown. Because these diseases do not appear to be of major concern in wildlife, they are not likely to result in detectable impacts from elk and bison management efforts, and they were therefore dropped from further analysis (Disease Expert Meeting 2002).

Vesicular stomatitis, an undocumented viral microparasite, is not analyzed in detail because no impacts are likely to be associated with this disease in elk (Disease Expert Meeting 2002). Foot-and-mouth disease and rinderpest are also not analyzed in detail because there are no records of these undocumented viral microparasites in United States, and if either became established in the United States, the national response would be major and very aggressive (Disease Expert Meeting 2002).

Documented Bacterial Microparasites — Bovine Brucellosis, Septicemic Pasteurellosis, Necrotic Stomatitis

Bovine Brucellosis

Elk, bison, and cattle, as well as many other mammals, are susceptible to infection by the bacteria *Brucella abortus*, which causes brucellosis (Davis 1990; Thorne 2001). The Jackson bison and elk herds are chronically infected with the disease. Brucellosis has been present in elk on the National Elk Refuge since at least 1930 (Murie 1951), and even though bison were declared brucellosis free in 1968 after several years of testing, samples collected in the late 1980s revealed that they had been reinfected either by the mid-1970s when they began wintering on the refuge, or possibly after they discovered the feedgrounds about 1980.

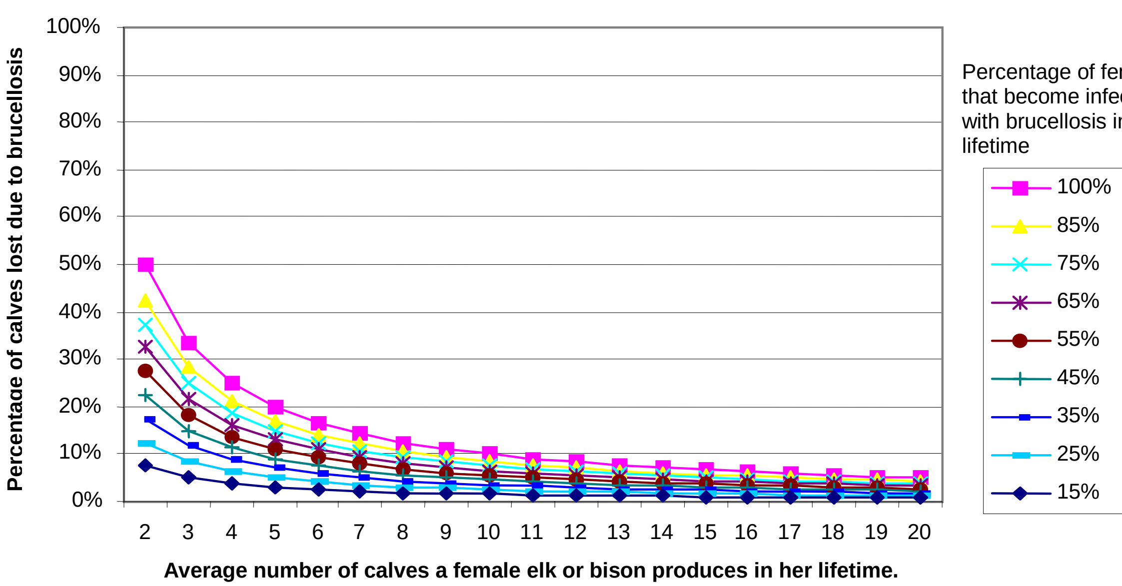
Transmission of brucellosis typically occurs when susceptible animals contact and ingest the bacterium *B. abortus* from infected aborted fetuses, fetal fluids, fetal membranes, or vaginal discharges (GYIBC 1997; Thorne 2001). Abortion is the characteristic sign of acute brucellosis, and there is no feasible treatment or cure for the disease (GYIBC 1997). Studies indicate between about 50% and 90% of females abort their first calf after infection (Thorne, Morton, and Ray 1979; Davis et al. 1990, 1991), but second and third pregnancies following infection tend to progress normally. This means that the higher the number of calves produced by females, on average, the smaller the impact brucellosis will have on overall calf production in a population. For example, if a female produces an average of 10 calves over her lifetime, and if 100% of all females become infected with brucellosis at some point in their lifetime, the estimated loss in calf production in the herd would be approximately 10%.

Opportunities for brucellosis transmission within the bison herd is high because animals tend to congregate. For example, the prevalence of brucellosis in infected free-ranging bison herds in Yellowstone National Park and Wood Buffalo National Park in Canada ranges from 25% (Tessaro, Forbes, and Turcotte 1990) to 70.3% (Roffe, Rhyan, et al. 1999). In the Jackson bison herd, which is much smaller than these other herds, winter feeding does occur, and measurements of seroprevalence in the herd range from 58% (Clause, WGFD, unpubl. data) up to 84% (Cain et al. 2001; GTNP unpubl. data). Therefore, brucellosis prevalence in bison herds can be high with or without winter feeding, and regardless of herd size. Still, winter feeding may exacerbate the infection by increasing the chance of contact with an aborted fetus or birth site (Disease Expert Meeting 2002). Meyer and Meagher (1995b) contend that the primary route of transmission among bison is through the milk to calves, rather than from aborted fetuses. However, even chronically infected herds still have abortion rates in the single digits (Herriges et al. 1989; Peterson, Grant, and Davis 1991a, 1991b; Smith and Robbins 1994), and fetuses have been infected (Williams et al. 1993). The frequency of brucellosis-induced abortions in the Jackson herd is not known, although there is no evidence that this is negatively affecting the growth rate of the bison herd (GYIBC 1997).

Brucellosis transmission among elk is generally thought to be largely influenced by high concentrations of elk associated with winter feeding programs. Without winter feeding, elk in the Greater Yellowstone Area have an average prevalence of 1.65% of the population, whereas refuge elk average 28.56%. No elk populations outside the Greater Yellowstone Area are known to be infected with brucellosis. This is because elk under normal (non-feedground associated) circumstances isolate themselves during birth and clean up birthing products at the site (Thorne 2001). Also, birth usually takes place in the spring. However, like bison, both experimentally infected (Thorne et al. 1978) and naturally infected elk (Thorne, Morton, and Ray 1979; Thorne 2001) are known to abort as a result of brucellosis and can do so in winter while supplemental feeding is being provided. Brucellosis-induced abortions of elk calves in the Jackson elk herd are estimated to account for 5%–7% calf loss (Oldemeyer, Robbins, and Smith 1993). A single brucellosis-induced abortion on a crowded elk feedground could expose many elk to brucellosis (Thorne 2001). Consequently, brucellosis in elk is primarily a problem among elk that utilize winter feedgrounds (Smith 2001; Thorne 2001).

Transmission of brucellosis from elk to cattle (Thorne, Morton, and Ray 1979) and from bison to cattle (Flagg 1983) has been documented in confined spaces, but rarely in nature. One cattle herd in eastern Idaho recently contracted brucellosis

FIGURE 3-1: ESTIMATED PROPORTION OF ELK AND BISON CALVES THAT COULD BE LOST DUE TO BRUCELLOSIS
Based on the Average Number of Calves a Female Produces in Her Lifetime



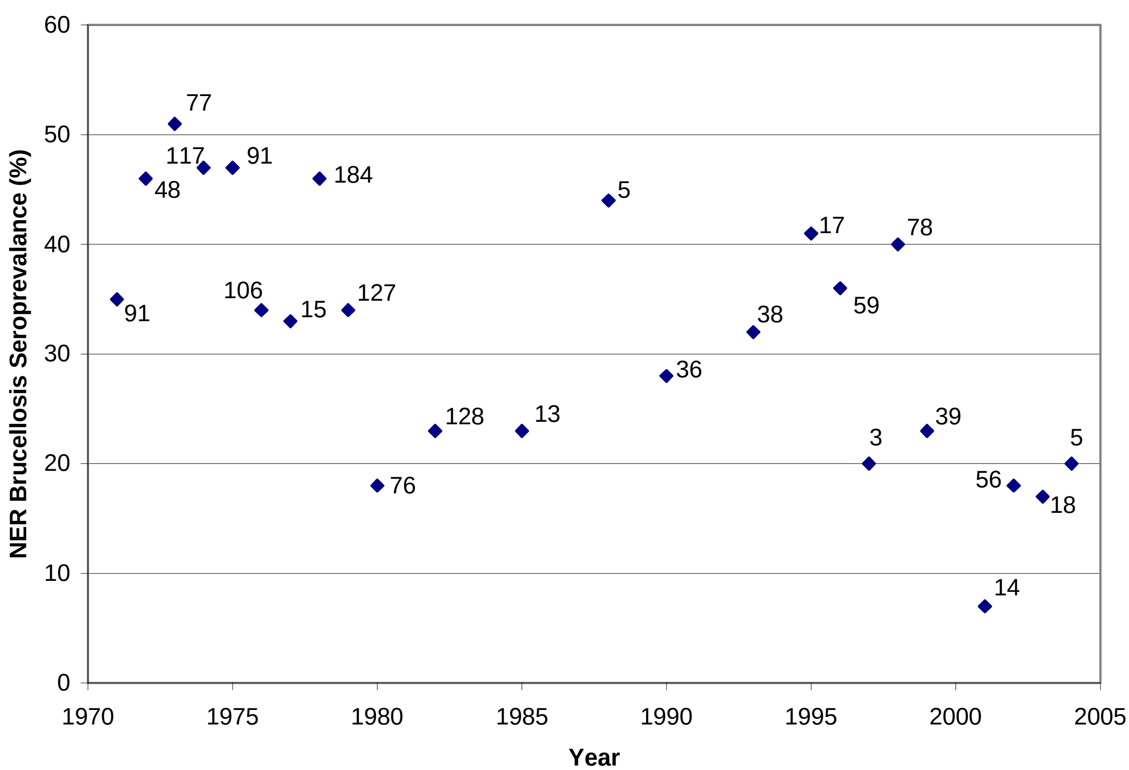
NOTE: These values are based on the fact that a female usually aborts her first calf following infection with brucellosis, and subsequent calves are born normally. Therefore, on average, each infected cow may lose one calf.

from infected elk (Hillman 2002). In Wyoming elk presumably infected a cattle herd in Sublette County in 2003 and at least one of two Teton County herds infected in 2004. Transmission from elk or bison to cattle would likely only occur when (1) infected pregnant elk or bison feed during the winter with cattle on a cattle feedground (Thorne 2001) and (2) cattle contact an aborted fetus and/or fluids, or an environment contaminated by infected birthing material during the period when abortions or birth may occur (for elk, February through June; for bison, mid-December through mid-June). As previously stated, transmission of brucellosis from elk to cattle is very unlikely during normal parturition because elk are meticulous about cleaning up their birth sites (Thorne 2001). Also, elk normally tend to isolate themselves when giving birth, further reducing the chance of cattle coming in contact with any contaminated material.

The Greater Yellowstone Interagency Brucellosis Committee has identified the following factors for the risk of brucellosis transmission from elk or bison to livestock (GYBIC 1997).

1. Separation in space and time reduces the potential for transmission. In addition to management separation, separation may occur as a result of differences in behavior, habitat selection, geographic features, and distribution in response to weather.
2. Risk of *B. abortus* transmission increases as the number and density of infectious animals in the host population increases.
3. Risk of *B. abortus* transmission increases as more susceptible animals associate with infectious animals.
4. The risk of transmission is affected by environmental factors. Outside its host, the *Brucella* organism has limited viability. Discharges will remain infectious for longer periods during cold weather. Direct sunlight quickly kills the organism. Scavenging by other wildlife reduces the occurrence of in-

FIGURE 3-2: PERCENTAGE OF BRUCELLOSIS-POSITIVE ELK TRAPPED ON THE NATIONAL ELK REFUGE, WINTERS 1970–71 THROUGH 2003–4



NOTE: The total number of elk tested each year is shown adjacent to each data point. Sample sizes varied from less than 30 in some years (1977, 1985, 1995, 1997, and 2001) to 184.

fectious tissues, but scavengers may also transport infected tissues.

5. The risk of *B. abortus* transmission from elk or bison to cattle is almost certainly confined to contamination by a birth / abortion event by adult females.
6. The risk of transmission may be reduced by vaccination, contraception, and herd size management.
7. Susceptibility varies with species, and some individual animals may be naturally resistant to infection.

The primary factor to consider when examining the risk for transmission of brucellosis from elk or bison to livestock is whether or not these species come into contact with each other or infectious birthing materials. In order to contract brucellosis, it is usually necessary for susceptible cattle to be present, or to arrive at the place where infected bison or elk abort or give birth. Therefore, any management alternative that reduces the chance for contact between bison or elk and livestock will reduce the risk to livestock.

No reliable data exist regarding exactly how the risk of intra- and interspecific brucellosis transmission decreases as a function of decreasing *B. abortus* prevalence in the bison or elk herd (GYIBC 1997), so a quantitative analysis of risk was not performed. Therefore, the impact assessment for this document is qualitative and based on information compiled from the literature and the opinions of wildlife disease experts (Disease Expert Meeting 2002). Seroprevalence serves as a useful index to actual *B. abortus* prevalence in these populations, and when prevalence is discussed in the impact analyses, it is assumed that seroprevalence is the measure used to indicate prevalence in the herds.

In general, brucellosis prevalence in bison and elk is more dependent on the intensity of a winter feeding program than on numbers of animals. When elk and bison are on feedlines, densities are much higher than what would be found on native winter ranges. Therefore, the primary management actions that could be implemented to reduce prevalence and transmission of brucellosis in these populations include greater dispersion of bison and elk through reductions in numbers or increasing movement and distribution. Vaccinating elk, cattle and bison; providing forage in elevated feeders; and testing and removing seropositive bison and elk could further reduce prevalence and the potential for transmission. In areas where both elk and bison are present, and there is no supplemental feeding program, interspecies transmission is low (Ferrari and Garrott 2002).

Septicemic Pasteurellosis

Pasteurellosis refers to several localized and systemic disease conditions of wild and domestic birds and mammals caused by various strains of *Pasteurella* (Thorne et al. 1982). The septicemic form of the disease is sometimes confused with hemorrhagic septicemia, a highly fatal disease of cattle and other ruminants.

Strains of *P. multocida* may be recovered from healthy elk, and if the elk are exposed to stressors such as infection by some other disease agent, or factors such as poor forage, overcrowding, or inclement weather, clinical disease may develop (Thorne et al. 1982; Thorne et al. 2002). Once clinical disease develops, the infected animal sheds great numbers of *P. multocida* in saliva and feces. It is transmitted by direct contact with feces, saliva, or aerosols of clinically infected animals. In acute cases, death is often the first clinical sign observed (Thorne et al. 1982).

Periodic outbreaks of septicemic pasteurellosis have occurred in the elk population on the National Elk Refuge in recent years, and there is some indication that increased stress (nutritional or environmental) increases susceptibility and may contribute to disease outbreak (Franson and Smith 1988; Thorne et al. 2002). The epidemiology of septicemic pasteurellosis in elk is not well understood, and it is not clear if the initiation of outbreaks is density dependent (Smith 2001; Disease Expert Meeting 2002). Outbreaks on the refuge have been related with extreme or harsh weather events (Franson and Smith 1988; Smith 2001). During the winter 1985–86, an outbreak occurred following several days of windy, rainy conditions, and then warm weather, which caused extremely muddy conditions. Mortality from this disease has been low on the refuge to date (B. Smith, pers. comm. 2003), and deaths from even the largest outbreak, which killed 160 elk in 1992–93, represented a negligible loss (1.8%) of elk wintering on the refuge (Smith and Anderson 1998).

Necrotic Stomatitis

Necrobacillosis refers to an array of diseases caused by the bacterium *Fusobacterium necrophorum*, of which necrotic stomatitis is one (Thorne et al. 2002). Necrotic stomatitis occurs in elk when punctures in the soft tissue of the mouth or throat, caused by eating coarse woody vegetation or grasses with large awns and seeds, become infected with *F. necrophorum* (Leighton 2001). Murie (1951) discovered that the primary cause of necrotic stomatitis on the refuge during the 1920s–1940s was the poor quality of grass hay being fed. Necrotic stomatitis should be considered a traumatic disease associated with consumption of poor forage rather than strictly a bacterial disease. In serious cases, the infections become chronic and the animals may lose teeth and eventually die of starvation. Bison are likely susceptible to other forms of necrobacillosis such as foot rot, but the thorough review of disease literature conducted for this document found no documented cases of necrobacillosis, or necrotic stomatitis in bison; therefore, the analysis in this EIS focuses on elk.

Currently there are only two to three elk mortalities per year from necrotic stomatitis on the refuge (Disease Expert Meeting 2002). The use of high-quality feed (alfalfa pellets), improving native winter range, and reducing elk densities have nearly eliminated the disease on the refuge.

Documented Macroparasites — Psoroptic Scabies, Helminths, and Lungworms

Psoroptic Scabies

Mites of the genus *Psoroptes* cause psoroptic scabies in a wide range of wild and domestic ruminants. Psoroptic scabies, also called psoroptic mange, is widespread in Wyoming among free-ranging populations of desert bighorn sheep, Rocky Mountain bighorn sheep, white-tailed deer, and elk, and it occurs in the Jackson elk herd (Smith 1985, 1998), where 4%–5% of males may be infected (Disease Expert Meeting 2002). Approximately 65% of bull elk that die on the refuge have been afflicted with scabies (Smith and Roffe 1994); however, not all animals exhibit clinical disease from infection with the mites.

Psoroptic mites are spread through direct contact, and prevalence in a herd is likely density related (Disease Expert Meeting 2002). Mature bull elk are more susceptible to psoroptic mites due to increased stress resulting from energy expended while rutting, poor nutrition following the rut, cold weather, crowding, and other diseases (Samuel, Welch, and Smith 1991). In severe cases skin damage from the mites may result in the animal's inability to maintain body core temperature, potentially leading to hypothermia (Samuel, Welch, and Smith 1991). In conjunction with other infections, psoroptic scabies may be a contributing factor resulting in death in some cases (Franson and Smith 1988).

Murie (1951) described scabies as a common winter phenomenon, affecting about the same proportion of the Jackson elk herd each winter but not an important factor in elk losses during average winters since many elk recover once spring and new green forage return. The condition affects individuals in poorer physical condition and with lowered resistance, and scabies may exacerbate the effects of other diseases. Murie considered the best precaution against scabies to be avoidance of overstocking and maintenance of "a good, productive elk range" (Murie 1951). Smith (1985) believed that physiological stress and malnourishment during the rut, not summer or winter nutritional status, was the most important factor in scabies-related mortalities.

During the winter of 2001–2, 61 mature bull elk on the refuge were classified as having scabies during a February survey and five bulls with clinical scabies had died earlier in the season. This amounted to 5.8% of mature bulls on the refuge (NER files).

Helminths and Lungworms

The lungworm, *Dictyocaulus viviparus*, is thought to be the most detrimental parasitic helminth (parasitic roundworm or tapeworm) known to occur in the Jackson elk herd (Smits 1991; Worley 1979). Other gastrointestinal parasites and helminths are only incidental in the Jackson elk and bison herds, and the effects on elk and bison are expected to be minimal under all management alternatives. Therefore, these other parasites are not considered in detail in this analysis.

In elk, loads of lungworms can be high, and lungworm infection is density dependent (Disease Expert Meeting 2002). Winter-feeding would contribute to high elk density, and lungworm infections would be greatest under winter-feeding conditions because lungworm larvae are shed in the feces. Elk are infected when they accidentally ingest larvae with vegetation (Thorne et al. 2002). Lungworm infection may lead to secondary infections and in conjunction with other stress factors such as severe weather, poor nutrition, forage depletion, or tick infestations may result in death (Thorne et al. 2002).

Undocumented Bacterial Microparasites — Bovine Tuberculosis, Bovine Paratuberculosis, Anthrax

Bovine Tuberculosis

Bovine tuberculosis, which is caused by the bacterium *Mycobacterium bovis*, has a worldwide distribution, and most mammals, including wild and domestic ruminants and humans, are susceptible (Clifton-Hadley et al. 2001). It has been reported in bison, elk, moose, mule deer and white-tailed deer (Hadwen 1942; Disease Expert Meeting 2002; Schmitt et al. 1997; Choquette et al. 1961; Broughton 1987). Free-ranging carnivores such as wolves, coyotes, bears, raccoons, and bobcats may become infected by consuming the carcasses of infected ungulates (Bruning-Fann et al. 2001); however, it is not likely to become established in predator and scavenger populations because these are dead-end hosts and do not transmit the disease (Disease Expert Meeting 2002). Currently, bovine tuberculosis is nearly eradicated from domestic cattle (Demarais et al. 2002), and no captive cervid herds in the United States are known to carry tuberculosis. In North America the only known reservoirs of bovine tuberculosis in the wild are white-tailed deer in Michigan, bison and other species in Wood Buffalo National Park, and an elk herd in Manitoba (Demarais et al. 2002).

This disease is normally chronic and is spread by means of aerosols or the consumption of contaminated food (Clifton-Hadley et al. 2001; Demarais et al. 2002). Transmission is directly dependent on the density of susceptible animals, and animals concentrated around feed troughs would further contribute to transmission (Demarais et al. 2002). Bovine tuberculosis has a long incubation period and can be difficult to detect in populations (Thorne et al. 2002). Therefore, it may be present within a herd long before it is detected; for this reason close monitoring is needed to detect the disease as early as possible. Currently, there is no evidence of bovine tuberculosis in the Jackson elk and bison herds (Rhyan et al. 1997; Williams et al. 1995). In northern Michigan it is thought that high deer densities caused by winter feeding serve to maintain bovine tuberculosis in the herd (Schmitt et al. 1997; O'Brien et al. 2002).

The prevalence of bovine tuberculosis in white-tailed deer in Michigan was 2.5% (O'Brien et al. 2002), and in elk at Wood Buffalo National Park in Alberta, where elk occurred in the same area as infected bison, it was 5.5% (Hadwen 1942). The gregarious nature of bison leads to a high functional density, allowing for high transmission and infection rates, and high disease prevalence. Joly, Leighton, and Messier (1998) found that bovine tuberculosis prevalence in Wood Buffalo National Park bison was 51%.

Bovine Paratuberculosis

Bovine paratuberculosis, or Johne's disease, is caused by the bacterium *Mycobacterium paratuberculosis* and is a disease of ruminants worldwide. *M. paratuberculosis* and *M. bovis* are similar and related diseases. Like tuberculosis, paratuberculosis is a chronic disease that develops very slowly and may take several years before clinical signs become evident. The majority of infected animals never develop clinical disease, but may shed the organism in feces (Williams 2001), and in the environment the bacteria may remain viable for a year or more under favorable conditions (Thorne et al. 1982). Once an animal develops clinical symptoms, it usually dies (Thorne et al. 1982). Transmission generally occurs from the ingestion of the bacterium (Thorne et al. 1982), and a high density of susceptible animals increases the likelihood of transmission (Williams 2001). Bison and elk are considered equally susceptible to the disease (Disease Expert Meeting 2002).

Paratuberculosis has been documented in both captive and free-ranging elk herds, and it is currently known to exist in a population of Tule elk in California (Jessup, Abbas, and Behymer 1981). It is also known to be present in several herds of bighorn sheep and mountain goats in one area of Colorado (Williams, Spraker, and Schoonveld 1979). There is no evidence of bovine paratuberculosis in the northern Greater Yellowstone Area (Rhyan et al. 1997) or in the Jackson elk and bison herds.

Anthrax

Anthrax, caused by the endospore-forming *Bacillus anthracis,* is an acute infectious and often-fatal disease in a wide array of wildlife, domestic animals, and humans (Gates, Elkin, and Dragon 2001). Cattle, bison, and elk are generally more susceptible to anthrax than humans, scavengers, and carnivores. When carcasses are torn apart by predators or scavengers, *B. anthracis* is released into the environment. Some of the bacilli may sporulate and remain viable in the environment for decades before colonizing new hosts. Endospores tend to concentrate in pools, wallows, and depressions, and anthrax outbreaks typically occur during warm, dry conditions when endospores are most concentrated. Animals typically contract the disease when they ingest spores off the soil. Under suitable soil and temperature conditions (pH higher than 6.0, moist soils, air temperature above 15.5ºC) spores may multiply (Thorne et al. 1982). For these reasons, anthrax is not likely to be contracted during the winter when temperature and moisture conditions do not favor spore multiplication. Direct animal-to-animal transmission of the organism does not occur; therefore, interspecies transmission is not a concern under any of the alternatives.

Anthrax has not been observed in the Jackson elk and bison herds, but it has been observed in cattle and moose in the Green River drainage southeast of Jackson Hole. These few individual cases suggest that, although anthrax is present, the disease cycle does not maintain itself well in this area (Roffe, pers. comm. 2003). The management alternatives would do little to affect the prevalence of anthrax in Jackson elk and bison herds, so this disease is not discussed further.

Undocumented Viral Microparasites — Malignant Catarrhal Fever

Domestic sheep are thought to be the source of this virus in bison and elk, and it is believed transmission may occur via aerosols (Thorne et al. 1982). Malignant catarrhal fever is probably the most infectious disease of captive bison in the United States, especially at high animal densities (Heuschele and Reid 2001; Haigh, Mackintosh, and Griffin 2002). The development of the clinical disease is generally stress related (density, starvation, inclement weather) (Haigh, Mackintosh, and Griffin 2002), and once clinical signs develop, mortality may be nearly 100% (Thorne et al. 1982). The west slope of the Teton Range is currently the closest location to Jackson Hole where domestic sheep grazing occurs.

Studies have shown that bighorn sheep are frequently seropositive for malignant catarrhal fever virus, but it is unknown if it can be transmitted from bighorn sheep to elk or bison. Other wildlife, including black-tailed deer, elk, mule deer, white-tailed deer, pronghorn, and moose, have tested seropositive for the disease, but the clinical disease has rarely been observed in these species (Zarnke, Li, and Crawford 2002). There are no reports of malignant catarrhal fever occurring in the Jackson bison or elk herds.

Undocumented Prion Diseases — Chronic Wasting Disease

Chronic wasting disease, a transmissible spongiform encephalopathy related to mad cow disease (bovine spongiform encephalopathy), could infect and spread rapidly through the elk herd. Its origin is unknown, although it is most similar to sheep scrapie. Eventually fatal, chronic wasting disease even contaminates the soil where the outbreak occurs. Hence, current management options are limited; infected animals are quarantined and killed. Although originally limited to north-central Colorado and southeast Wyoming, recent outbreaks in other western states have heightened concern about its spread due to the serious consequences of infection and its relationship to mad cow disease and a mad cow variant that has killed humans.

Chronic wasting disease is caused by a deleterious prion protein and is both infectious and contagious (Williams, Miller, et al. 2002). The disease is transmitted between animals, but the exact mode of transmission is unknown (Williams, Miller, et al. 2002). The dynamics of this disease in elk and deer populations are still poorly understood. However, transmission does appear to be related to the density of susceptible hosts.

Based on current information, only elk, mule deer, and white-tailed deer are susceptible to chronic wasting disease (Williams, Miller, et al. 2002). In instances when pronghorn, moose, bighorn sheep, mountain goats, cattle, sheep, and goats were in the same facilities as deer and elk infected with chronic wasting disease or when they resided in facilities where chronic wasting disease had occurred, none developed the disease (Williams, Miller, et al. 2001).

Chronic wasting disease was first identified in mule deer in the late 1960s at captive research facilities in Colorado (Williams and Young 1980). In the early 1980s the disease was found in free-ranging elk in Wyoming and mule deer in both Wyoming and Colorado (Williams, Miller, et al. 2002). The spread of chronic wasting disease in North America has been advanced through natural animal dispersal and migration, and the transport of captive, infected cervids. The spread of the disease has been unpredictable (Williams, Miller, et al. 2002) and far reaching. As of May 2005, chronic wasting disease has been found in free-ranging elk, mule deer, or white-tailed deer in Wyoming, Colorado, Utah, Nebraska, South Dakota, New Mexico, Wisconsin, Illinois, and New York (see the "Chronic Wasting Disease in North America (2002–2005)" map). In 2003 chronic wasting disease was reported near Worland, Wyoming, approximately 90 miles east of the Jackson elk herd unit boundary. In Colorado and Wyoming chronic wasting disease has been moving westward in the past several years, and is now found west of the Continental Divide (see the "Chronic Wasting Disease in Wyoming (2003–2004)" map). Surveillance in Jackson Hole is being conducted, and chronic wasting disease has not been detected in the Jackson elk herd or mule deer herd.

Mule deer in Jackson Hole migrate south and east to spend the winter on the mesa south of Pinedale, Wyoming. This migration could be a potential way for chronic wasting disease to be transported into Jackson Hole. However, chronic wasting disease may not necessarily become established in the elk herd if an infected animal is present, because an infected animal could spend the summer and winter in low-density situations, where it might die without transmitting the disease.

The spread of chronic wasting disease to the Jackson elk herd is possible, and it may be just a matter of time until it is introduced. Presently, infected captive deer and elk herds are depopulated or quarantined, but some infected herds may remain. With increasing awareness of this disease, states are beginning to place moratoriums on movement of captive cervids, and the U.S. Department of Agriculture is adopting a herd certification program (Williams, Miller, et al. 2002).

Prevalence of chronic wasting disease in free-ranging wildlife can range from 2% to 4% in elk and 15% to 18% in deer (Miller and Williams 2003). In confined situations prevalence can be much higher. In an affected elk game farm in Nebraska, prevalence in white-tailed deer within the fenced boundary reached over 50%. In research facilities where chronic wasting disease was first discovered, virtually 100% succumb to the disease (Roffe, pers. comm. 2003). Few game farm prevalence levels have been published, and prevalence is highly variable depending on management and duration of infection. The prevalence in game farm elk may reach up to 59% (Peters et al. 2000).

If chronic wasting disease does become present in the herd, environmental contamination will become a major concern due to the disease's ability to persist in the environment for a long period of time, even after intensive efforts to eradicate it.

Transmission appears to be from animal to animal, or environment to animal and is spread by means of feces or saliva or contact with carcasses or residual environmental contamination (Williams et al. 2002). Data on infection caused by environmental contamination at the Sybille research unit in Wyoming and research facilities at Fort Collins, Colorado, indicated that the infectious agent is long lasting (Madsen 1998). Previously unexposed deer and elk were infected within five years after being placed in Sybille pens that had been empty of infected animals for six months to a year. At the Fort Collins facility, 2 of 12 elk calves became infected and died within five years of being placed in sanitized pens, pens that had been plowed, sprayed repeatedly with a strong disinfectant, and left empty for a year before the calf introduction.

Map

Chronic Wasting Disease in North America (2002–2005)

Map

Chronic Wasting Disease in Wyoming (2003–2004)

The U.S. Fish and Wildlife Service and the National Park Service can do little to prevent Jackson Hole mule deer and elk from contracting chronic wasting disease from other ungulates outside the Jackson elk herd unit and transporting it into Jackson Hole. Some precautionary measures, such as reducing densities and numbers of elk and increasing dispersion, could reduce the chance of major adverse impacts if the disease became established (Roffe, pers. comm.).

HUNTING

Hunter harvest accounted for nearly 90% of adult mortality in the Jackson elk herd during the 1990s (Smith 2000). The harvest rate has averaged 20% of the herd during the last 20 years. Annual harvest from 1998 to 2002 ranged from about 2,300 to 3,300, and approximately 16% of the pre-hunt Jackson elk herd population was removed. Smith and Anderson (1998) found that females one year or older outsurvived males in the same age class during the fall hunting season (0.890 and 0.729, respectively).

Harvest rates from 1978 to 1984 differed for elk summering in Grand Teton National Park (17%) and those summering outside the park (24%) (Smith and Robbins 1994). Later harvests (1991–93) showed the same percentage for elk in the park, but outside the park seasons were more restrictive, and the harvest rate decreased from 24% to 16% (Smith and Anderson 1998).

In addition to WGFD harvests in Bridger-Teton National Forest and on nonfederal lands, hunting occurs on the refuge each fall, along with the elk reduction program in the park. Over the last 20 years harvest in the park has contributed about 25% to the total harvest, and harvest on the refuge has contributed about 10%. The remaining 65% of the harvest takes place mainly in the national forest.

PREDATION

Predators were not considered an important influence on ungulate populations throughout much of the 20th century because of low numbers in many areas (Raedeke, Millspaugh, and Clark 2002; Murie 1951; Boyce 1989). However, the colonization of Jackson Hole by wolves reintroduced into Yellowstone National Park in 1995 and recent range expansion by grizzly bears in the southern greater Yellowstone ecosystem have increased interest in the effects of predators on elk.

As of the winter of 2004, the total number of elk killed by wolves each winter in the Gros Ventre area is estimated to represent less than 1% of the herd (USFWS et al. 2005). Researchers documented 255 elk killed by wolves in the Gros Ventre feedground area from 2000 to 2004 (48 in 2000, 19 in 2001, 52 in 2002, 81 in 2003, and 55 in 2004). The number of wolf-killed elk in 2001 was low because researchers had difficulty gaining access to wolf hunting areas due to poor snow cover.

In the winter of 1998–99 wolves preyed on elk on the National Elk Refuge for a two-month period, killing 1% of the elk counted on the refuge feedgrounds. Because the winter census was identified as only a partial count of the refuge feedground elk, the percentage actually killed was likely less than 1%. Since then, wolves have preyed only incidentally on the refuge up until the winter of 2004–5. An accurate count of wolf-kills is not available for this most recent winter. Winter kill rates have been shown to be variable during the winter, as well as between winter seasons (D. W. Smith et al. 2004). Because little is known about summer kill rates in any ecosystem, winter data should not be extrapolated to estimate annual rates (WGFD 2003).

Some studies have indicated that predators may affect specific age and sex classes of elk and that influences differ among predator types (Raedeke, Millspaugh, and Clark 2002). Calves in particular are vulnerable, especially during the first 30 days of life (Singer et al. 1997) and are preyed on mainly from mid-May through early July by grizzly bears in Yellowstone National Park (Gunther-and Renkin 1991). Hornocker (1970) found that cougars killed more bulls and calves than adult and yearling cows. In and near Glacier National Park in Montana wolves and cougars mainly killed the most vulnerable prey, for example, the young, old, or poor-conditioned, and did so more than hunters did (Kunkel et al. 1999). Carbyn (1983) also reported that one wolf pack in Riding Mountain National Park in Manitoba killed a high percentage of older elk (47% were 11 years of age or older), and as winter progressed, they killed more adult cows than earlier in the season.

Map

Existing Elk Hunting Areas

Predators on elk in the Jackson area include wolves, cougars, grizzly bears, black bears, and coyotes. Black bears primarily prey on calves, and only occasionally on adult elk (Barmore and Stradley 1971, cited in Boyce 1989). Coyotes prey on calves opportunistically but are often unable to because adult elk are large-bodied and, if nearby, capable of defending their young against these relatively small carnivores (Geist 1982). More detailed discussion about individual predator species is in the "Predators and Scavengers" section (beginning on page 156).

Elk Recruitment and Wolves

This subject is treated in some detail because of public concern about the recent decline of calf-to-cow ratios in the Jackson and northern Yellowstone herds and requests to address the effects of a growing wolf population on calf recruitment.

Pregnancy rates, birth rates, and calf survival affect elk recruitment, which is reflected in calf-to-cow ratios. These parameters are in turn influenced by a number of factors such as elk density, habitat loss, habitat condition, nutrition, predation, environmental conditions, disease, cow condition, bull and cow age structure, birthday, birth weight and condition, bull/cow ratios, human disturbance, and legal and illegal human harvest (Caughley 1974; Mitchell and Crisp 1981; Caughley and Sinclair 1994; Thorne, Dean, and Hepworth 1976; Cook et al. 1996; Zager and Gratson 1998; Smith and Anderson 1996, 1998). These factors interact in complex ways, making it difficult to determine the cause of population fluctuations. The influence of predators on their prey may vary from one area to another, at different times, and for different reasons (WGFD 2003). Ongoing research in Washington, Oregon, Idaho, and the greater Yellowstone ecosystem is looking at how these factors affect recruitment in elk herds.

Of Washington State's 10 elk herds totaling approximately 56,000 Roosevelt and Rocky Mountain elk, 8 herds are below objective (Washington Department of Fish and Wildlife [WDFW] 2002) and several of these have lower calf-to-cow ratios than they did in the 1970s or 1980s. Factors attributed to the declines include the loss of habitat from development and prevention of fires, increased hunting, conflicts with agriculture, and predation by mountain lions and black bears (Nelson 2001). Although elk populations in Oregon are generally doing well, those in the northeastern part of the state (Wallowa and north Umatilla counties) have seen calf-to-cow ratios decline from a high of 42 calves/100 cows in 1979 down to 19 calves/100 cows in 2000 (Oregon Department of Fish and Wildlife [ODFW] 2001). The cause of the decline is unclear, but climate, density-dependent interactions, habitat degradation, and predation by mountain lions and black bears have all been proposed as potential causes. Many game management units in north-central Idaho also experienced chronically low or declining elk recruitment since the 1980s or early 1990s, before wolves were reintroduced (Gratson and Johnson 1995). Although most elk herds in Montana are at or above herd objectives (Lemke, pers. comm. 2003), herds across almost all areas of elk habitat have experienced declines in calf-to-cow ratios of 30% to 50% from historical averages (Montana Fish, Wildlife and Parks 2002). This includes elk herds both where wolves do and do not occur.

All Wyoming elk herds adjacent to Yellowstone National Park have been over WGFD objectives for several years (WGFD 1990–2002). Some of these herds are experiencing lower calf-to-cow ratios or declines in numbers, but the relative degree to which wolves, the drought, high elk densities, habitat decline, hunter harvest or other factors are causing the decline is not known. Declines in Montana are occurring both where wolves are present and where they are not. Four elk herds in Wyoming not subject to wolf predation are also experiencing declining calf-to-cow ratios, although their ratios are currently higher than those in the Jackson herd or the northern Yellowstone herd. These are the South Bighorn elk herd, the Rattlesnake elk herd, the Iron Mountain elk herd, and some units of the Sierra Madre elk herd (WGFD "2002 Annual Big Game Herd Unit Report").

The northern Yellowstone elk herd has received particular scrutiny in recent years because of public concern that the wolf population will reduce elk numbers (*Billings Gazette* 1999, 2002). Surveys have shown that pre-wolf variability in this herd was high, and numbers have ranged from less than 9,000 to about 19,000 elk since the 1970s. The annual winter count typically changes 10%–20% from year to year, but sometimes by as much as 30%–40% (Montana Fish, Wildlife and Parks

[MFWP] 2002). Compared to other elk herds in Montana, the northern Yellowstone herd has been more dynamic and has not exhibited clear, long-term trends. The herd is subject to natural population influences on half or more of its range.

The greatest single factor affecting elk numbers in the northern Yellowstone herd is periodic, large winter-kill events that do not occur in other Montana elk herds, even in harsh winters. These winter kills result from several factors particular to this herd and this area, including severe winter conditions, an older age structure in the population, high elk densities, and complete reliance on native forage with no agricultural base (MFWP 2002). The northern herd has demonstrated the ability to recover from periodic population declines, growing from 3,200 elk remaining after decades of elk reduction ceased in Yellowstone in 1968 to over 12,000 by 1976. Elk numbers typically recover from winter kill events within five to six years (MFWP 2002).

Biologists have concluded that the data suggest that elk abundance has decreased since 1988 (Northern Yellowstone Cooperative Wildlife Working Group, cited in MFWP 2002), and like other areas of Montana, calf-to-cow ratios have also dropped in the northern herd, from an average of 32 calves/100 cows to a low of 14 calves/100 cows in 2002. However, calf recruitment in Yellowstone varies widely from year to year, ranging from 14 to 48 calves/100 cows. Yellowstone elk have also typically had lower recruitment than other elk herds in Montana due to higher predation rates from all predators, lower pregnancy rates, an older age structure in the female segment of the herd, long stressful winters, and the general physical condition of elk, which varies with forage availability and quality (MFWP 2002). The herd does not appear to be outside the normal range of variability. Montana Fish, Wildlife, and Parks has concluded

> While there are many factors that affect elk herd numbers (i.e., winter severity, weather during hunting season, drought conditions, predation, and hunter pressure), the available data on the northern Yellowstone elk herd suggests that current herd size, hunter effort, and hunter success are within the general ranges seen before reintroduction of wolves (MFWP 2002).

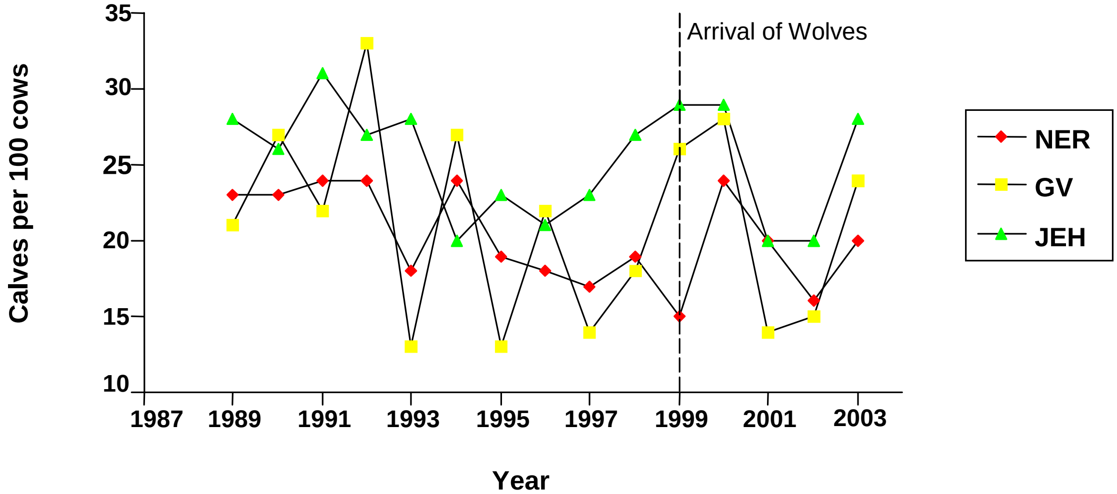
In the winter 2003–4 the Jackson elk herd was estimated at approximately 13,500, almost 2,500 elk over the objective of 11,029. The herd has been over objective since 1987, and hunter harvest has been liberal in the last 10 years to intentionally bring the number down to the objective.

In the winter of 1998–99 wolves hunted on the refuge feedgrounds for the first time since wolf reintroduction in 1995. Although 60 elk mortalities from all causes were verified, biologists assume that only 50% of the elk that died on the refuge were discovered by refuge employees. Therefore, 120 elk or 1.4% of the refuge population, are estimated to have died in 1999. Of the 60 elk carcasses that were discovered, approximately 30 were determined to have been killed by wolves. USFWS biologists extrapolate that approximately 60 elk were killed by wolves in the winter of 1998–99 on the refuge (B. Smith, pers. comm. 2003). Of 30 verified wolf-killed elk, 77% were calves. Since wolves arrived in Jackson Hole in the winter of 1998–99, winters have been mild and elk abundant. After that first winter, the presence of wolves on the refuge has been minimal or nonexistent, while the Gros Ventre feedgrounds have had a significant wolf presence (USFWS et al. 2003). Even so, less than 1% of the total Jackson elk herd has been killed by wolves each winter since 1999–2000 (See Figure 3-3) (WGFD 2003).

Approximately 50% of the elk that feed on the refuge come from Grand Teton National Park, while 25% each come from Yellowstone and Bridger-Teton National Forest. Elk summering in the park experience very little non-winter wolf predation for at least six months of the year (Jimenez, pers. comm. 2003); whereas elk summering in Yellowstone and the national forest experience predation from wolves even when not on the Gros Ventre feedgrounds.

The calf-to-cow ratios on the refuge and on the Gros Ventre feedgrounds appear to fluctuate regardless of whether wolves are present. On the Gros Ventre feedgrounds the calf-to-cow ratios actually increased the first year after wolves arrived at that location (winter 2000–2001), declined in the following two winters, but rose again in 2003–4. The National Elk Refuge ratio rose in 1999–2000, remained steady in 2000–2001, declined in the next two years, and also rose in 2003–4, despite the near absence of wolves throughout

FIGURE 3-3: NUMBER OF CALVES PER 100 COWS ON WINTER FEEDGROUNDS ON THE NATIONAL ELK REFUGE, IN THE GROS VENTRE RIVER DRAINAGE, AND IN THE JACKSON ELK HERD OVERALL



NER — National Elk Refuge GV — Gros Ventre River Drainage JEH — Jackson Elk Herd

this entire time. The decline in calf-to-cow ratios on the refuge and in the Jackson herd is therefore apparently linked to a combination of factors, such as prolonged drought, human harvest, older cows, and other predators, in addition to wolves. Before any definitive conclusions can be drawn about the effects of wolves on their prey, more research must be done, taking into consideration the multiple environmental and human factors that affect prey populations.

FACTORS AFFECTING CALF-TO-COW RATIOS

HABITAT AND HIGH ELK DENSITIES

When elk densities increase above what the habitat can support, elk become nutritionally stressed, which can result in lower pregnancy rates, reabsorbed fetuses, low-weight newborns, and calves that grow at slower rates (Houston 1982; Merrill and Boyce 1991; B. Smith, pers comm. 2002). In Idaho statewide aerial surveys indicate that elk density negatively affects elk recruitment on a broad scale (Gratson and Johnson 1995; Bomar et al. 2000). When elk densities were decreased experimentally, recruitment rates went up (Gratson and Zager 1994). High elk densities and reduced recruitment rates have also been documented for the northern Yellowstone elk herd (Houston 1982; Merrill and Boyce 1991; Coughenour and Singer 1996), and the Jackson elk herd (Boyce 1989). Although analyses by Smith and Anderson (1998, 2001) did not find that the Jackson elk herd density from 1990 to 1994 influenced juvenile survival and dispersal, analysis of data from 1980 to 2002 indicated that neonate (young in the first few months of life) survival decreased at higher population sizes (Lubow and Smith 2004). The density influence was weak at current population size and recent supplemental feeding levels.

Habitat sets the potential upper limit on elk density (Caughley 1977; Caughley and Sinclair 1994). Intrinsically poor habitat will not support even moderate or low elk densities and will result in low recruitment rates. On the other hand, high elk densities can degrade habitat conditions, affecting elk nutrition and leading to calves in poor condition with higher rates of starvation, predation, and disease. Coughenour and Singer (1996) found that winter calf mortality rates increased with population density. These findings agree with DelGiudice's (1991) study indicating that nutritional deprivation was related to high ungulate densities, deep snow, and declines in calf-to-cow ratios from early to late winter.

Calf Condition

The condition of elk calves can depend on the condition of cows while pregnant and lactating, which in turn is related to the condition of the habitat. A nutritionally stressed cow may give birth to a lower birthweight or weak calf or have insufficient milk to feed it, increasing the calf's chances of dying from starvation, disease, accident, or predation (Clutton-Brock, Guinness, and Albon 1982; Clutton-Brock, Albon, and Guinness 1989; Clutton-Brock, Price, and MacCall 1992; Kunkel and Mech 1994; Smith, Peterson, and Houston 2003), or reducing its growth rate. If nutritious forage is scarce, elk calves will be unlikely to successfully compete with adult elk (Knight 1970; Houston 1982).

The time of year that a calf is born can affect its potential for survival. Calves born out-of-season, either earlier or later than normal, may be at greater risk from predators and may be born before or after the peak season for forage production, leaving them nutritionally at a disadvantage. Calves born late in the season will go into their first winter smaller and weaker than average and less likely to survive severe winter conditions (Clutton-Brock, Guinness, and Albon 1982; Clutton-Brock et al. 1987).

Some studies have tried to determine if predation on calves is additive or compensatory. In other words, if wolves kill calves that ultimately would have died from starvation or disease, the predation is said to be compensatory mortality. A western Wyoming study by Smith, Peterson, and Houston (2003) suggests that the predation mortality on elk calves was at least partially compensatory because predators tended to select inferior calves with lower-than-average growth rates. A second study in Idaho supports this conclusion, finding that wolves, even more than cougars, took prey that was malnourished and in a weakened condition (USFWS et al. 2003).

This compensatory/additive issue, which needs more long-term study, is important because if predation is largely compensatory, the Jackson elk population will continue to be only negligibly affected by wolf predation, and the number of elk available for human harvest will not change. If wolf predation is largely additive, hunter harvest may need to be adjusted to compensate for the increased mortality due to the expansion of wolves and grizzly bears, or wolf and grizzly bear populations may need to be managed at a lower level.

Weather

Weather conditions in the spring and summer can also affect calf condition and calf recruitment. Cooler April temperatures and larger elk numbers coincided with declining weight gains and lower survival of calves in the Jackson elk herd (Smith, Peterson, and Houston 2003). Coughenour and Singer (1996) found that forage biomass and calf recruitment increased with higher precipitation levels. While severe winter conditions can negatively impact adults and calves, calves are even less likely to be able to cope with high snow levels and compete with adults for the limited forage available.

Habitat Successional Changes

Forest management practices can influence habitat suitability for elk and other ungulates. Elk generally do well in habitat that is in early to mid-successional stages (Nelson 2001).

As timber harvest practices change and more land is allowed to shift to late successional stages, the forests become less productive for elk. Fire suppression has also accelerated the shift to late successional stages (Fowler 2001).

The spread of nonnative invasive plants is threatening forage conditions in many areas. Roads and off-road vehicle use facilitate the spread of nonnative invasive plants that compete with palatable native forage (Fowler 2001)

Human Disturbance

Inactivity in winter provides an energetic advantage to animals exposed to cold weather, while forced activity caused by human disturbance exerts an energetic cost (Canfield et al. 1999). The expression of this cost may manifest in an increase in general alertness, slow retreating movement, and outright flight. Actual displacement of animals may not be necessary to cause high energy expenditures (Chabot 1991). Tests on various ungulates confirm that an increased heart rate as a result of even minor, seemingly harmless human disturbance causes increased energy expenditures (Freddy 1984; Weisenberger et al. 1996; Fancy and White 1985a, 1985b; Moen, Whittemore, and Buxton 1982; Ward and Cupal 1976; Lieb 1981; MacArthur, Geist, and Johnston 1982; Geist, Stamp, and Johnston 1985; Cassirer, Freddy, and Ables 1992). Intentional or unintentional human harassment may be debilitating to ungulates, resulting in illness, decreased reproduction, and even death (Geist 1978). Excessive road density limits habitat suitability in most managed forests, allowing access by recreationists and illegal human harvest (Nelson 2001; Malaher 1967).

A general increase in human disturbance (including hiking, bird-watching, photography, hunting, and antler hunting), and in particular an increase in snowmobile and four-wheel vehicle use, may cause considerable stress to elk, especially during the breeding season and the winter when elk need to conserve energy to compete in the rut and survive harsh weather conditions (Fowler 2001). Indiscriminate off-road vehicle use not only causes environmental damage, but can reduce the size of ungulate home ranges, force ungulates into less preferred habitat, physically stress animals, and frighten calves from their beds, exposing them to predators (Dorrance, Savage, and Huff 1972; Geist 1971). Limiting vehicular access has been shown to reduce human disturbance and poaching of elk (Cole, Pope, and Anthony 1997; J. L. Smith et al. 1994; Phillips and Alldredge 2000).

COW AGE STRUCTURE

Cow elk are thought to typically decline in reproductive fitness after the age of 12–14 years, but pregnancy rates may vary from population to population (Raedeke, Millspaugh, and Clark 2002). In a Michigan study Rocky Mountain elk older than 7 years had a pregnancy rate of 53%, while elk from 3 to 7 years had a pregnancy rate of 84% (Moran 1973). Eight female elk over the age of 11 years were examined in western Oregon and none was reported pregnant (Trainer 1971). Populations with large numbers of old cows are likely to have lower calf-to-cow ratios and lower recruitment. Estimates of the pregnancy rate in the northern Yellowstone elk herd vary, between 70% (Lemke, pers. comm., 2003) and 95% (White, pers. comm. 2003). The pregnancy rate for the Jackson herd is 87%, but the actual number of calves born in the spring (the natality rate) is approximately 63% (Smith and Robbins 1994). The southern Yellowstone and Grand Teton National Park segments of the Jackson elk herd are thought to have a higher number of old cows due to supplemental feeding in the winter and little or no exposure to human harvest. Many elk in these herd segments avoid the fall elk reduction program by staying on the west side of the Snake River and crossing to safe zones on the National Elk Refuge at night (B. Smith, pers. comm. 2002).

BULL AGE STRUCTURE AND BULL-TO-COW RATIOS

Some studies indicate that elk populations where there are few older bulls and where much of the breeding is performed by less efficient yearling bulls, exhibit lower pregnancy rates (Cheatum and Gaab 1952; Greer 1966; Greer and Hawkins 1967). It is hypothesized that these populations will also have conception dates that are later and more spread out, resulting in later-born calves and higher over-winter calf mortality (Follis 1972; Prothero 1977; Kimball and Wolfe 1979; Noyes et al. 1996). Data from seven national parks showed a ratio of about 50 bulls to 100 cows, with about two-thirds of the bulls older than yearlings (DeSimone et al. 1993). Bubenik (1985) suggested that a ratio of 25 mature bulls to 100 cows was needed for satisfactory calf-to-cow ratios, while research by Noyes et al. (1996) indicated that a ratio of 18 mature bulls to 100 cows was adequate. A study in Colorado found that calf-to-cow ratios declined when there were fewer than 10 mature bulls per 100 cows (Freddy 1987).

LEGAL AND ILLEGAL HARVEST

Some hunt programs allow the taking of calves during the hunting season, likely resulting in lower post-season calf-to-cow ratios. Poaching may also take a toll, but it is hard to determine what the effect on the calf population may be.

PREDATION

Newborn calves may be taken by black bears, grizzly bears, mountain lions, wolves, and coyotes (Gese and Grothe 1995; Myers et al. 1998; Singer et al. 1997; Smith and Anderson 1998; Smith, Peterson, and Houston 2003). Black bears appear to cause a substantial amount of mortality in the first months of a calf's life, causing a documented 42%–72% of mortality in marked calves in various studies (Smith and Anderson 1996; Schlegel 1976; Zager, White, and Gratson 2002). See discussion under "Other Wildlife" for more detail.

Summary of Other Causes of Mortality

Besides hunting, disease, and predation, other causes of mortality include motor vehicle collisions and natural causes such as drowning (particularly in the spring when river water levels are high) and becoming mired in bogs (a relatively rare occurrence).

GENETICS

Long-term population genetic variability, which affects population fitness, is strongly influenced by population size and rates of immigration (the addition of animals from other populations). For genetically isolated populations, as population size decreases, inbreeding coefficients and the potential for deleterious effects on fitness increase. Population size is important in preserving variability as well. If a population is not genetically variable, it may not be able to survive changing environmental conditions.

Although no work on Jackson elk genetics has been done, viability of the Jackson herd has not been of concern due to large numbers of elk and the potential for mixing with individuals from Yellowstone and other adjacent populations. Microsatellite mtDNA data suggest that Yellowstone National Park elk are among the most genetically diverse in North America (Polziehn, pers. comm. 1999, cited in O'Gara 2002).

AREAS OF COMPETITION WITH BISON

Singer and Norland (1994) found a low to moderate degree of diet overlap between bison and elk, although the two species share a high degree of habitat overlap. During a period in which both species increased rapidly following release from artificial control, neither bison nor elk appeared to suffer any decrease in population growth due to competition from the other species. It is possible that stimulation of production and nutrition in grasses may have resulted in a beneficial effect for both species at observed population levels (Singer and Norland 1994).

THE JACKSON BISON HERD

HISTORY OF BISON IN JACKSON HOLE

Bison Populations Prior to Euro-American Settlement

The American bison is native to Jackson Hole (Fryxell 1928; Ferris 1940; Skinner and Kaisen 1947; Haines 1955; Hall and Kelson 1959; Long 1965; Love 1972; Wright et al. 1976; McDonald 1981). Prehistoric bison remains have been found throughout the valley, along the Gros Ventre River, on the west slope of the Gros Ventre Range, on the National Elk Refuge, and along the Snake River south of Jackson (Fryxell 1928; Ferris 1940; Love 1972). Historically, bison likely inhabited the northern areas of Jackson Hole as well, especially in summer. Areas where bison remains have been found represent key ungulate wintering areas, where most bison mortality would be expected to occur.

The number of bison that once inhabited the valley is unknown. At least one reference exists, however, for an observation of "a large herd of buffalo in the valley" during June 1833 (Ferris 1940). The near extinction of the American bison occurred throughout the 19th century. By the 1820s bison were confined almost exclusively to lands west of the Mississippi River. Many of these herds began to decline after 1830, as market hunting for hides accelerated, and prolonged drought in the 1840s further reduced bison numbers. After the Civil War, competition from domestic cattle and greatly intensified market hunting for "buffalo" robes and tongues decimated the Great Plains herds. Tourists on railroad shooting excursions killed thousands more. A final contributing factor was the introduction of cattle-borne contagious diseases, which reached epidemic proportions in 1881 and 1882. The combination of cattle, hunting, and epidemic disease all but eradicated the once immense western herds. Bison were mainly extirpated from the Jackson Hole and Greater Yellowstone area by the mid-1880s (Trenholm and Carley 1964). A small herd continued to exist in Yellowstone National Park (Bailey 1930, as cited in Long 1965; Wright 1984). By 1890 only about 300 bison remained in the United States (Malone, Roeder, and Lang 1976). While private herds existed throughout the United States, by 1902 no more than 23 individual bison remained of the thousands that had occupied the Yellowstone area since prehistoric times (Callenbach 1996). A small group of 8–12 free-ranging bison, whose origin is unknown, persisted in west-central Wyoming's Red Desert until the mid-1950s (Love, pers. comm., as cited in NPS and USFWS 1996).

The Jackson bison herd is of special importance as one of the last remnants of the extensive wild herds that once roamed much of North America. As bison continue to inhabit the landscape of what remains of the western frontier, a part of the unique American experience is preserved for future generations.

Jackson Hole Wildlife Park

With the exception of three Yellowstone bison that wandered south into Jackson Hole in 1945 (Simon n.d.), bison were absent from Jackson Hole from at least 1840 until 1948. That year 20 animals (3 bulls, 12 cows, and 5 calves) from Yellowstone were reintroduced to the 1,500-acre Jackson Hole Wildlife Park near Moran. This was a private, nonprofit enterprise sponsored by the New York Zoological Society, the Jackson Hole Preserve, Inc., and the Wyoming Game and Fish Commission (Simon n.d.). It served as an exhibit of important large mammals, as well as a biological field station for the Rocky Mountain area. The 20 bison were considered the property of Wyoming.

In 1950 the expansion of Grand Teton National Park took in the Jackson Hole Wildlife Park, and management of the bison shifted to the National Park Service. By 1963 the Park Service coordinated most management actions with the Wyoming Game and Fish Department. Management actions consisted primarily of winter feeding, capturing bison that escaped the confines of the wildlife park (which occurred several times annually), and routine brucellosis testing and vaccination. A population of 15–30 bison was maintained in a large enclosure until 1963, when brucellosis was discovered in the herd. Several months later, all 13 adults in the population were destroyed in order to rid the herd of the disease. Four yearlings that had been vaccinated against brucellosis as calves and five new calves, which were also vaccinated, were retained.

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

Bison on the National Elk Refuge

The free-ranging bison established fairly well-defined movement patterns in Grand Teton National Park, spending summers in the Potholes / Signal Mountain / Snake River bottoms area and wintering in the Snake River bottoms and farther south (see "Jackson Hole Bison Herd Seasonal Ranges" map). During the early 1970s they wintered in the river bottoms north of Moose and in the Kelly hayfields vicinity, east of Blacktail Butte. Since the winter of 1975–76, however, most of the herd has wintered on the National Elk Refuge (except during the mild winter of 1976–77).

Herd Management Actions

Between 1969 and 1985 few bison management actions were taken. The size of the herd and its sex and age composition were documented on an opportunistic basis. Soon after the bison began wintering on the National Elk Refuge, they discovered the supplemental feed put out for the elk. Although efforts to haze the animals away from feeding areas took place, they were largely unsuccessful. Consequently, the refuge staff resorted to liberally feeding bison to keep them away from elk feedlines and to minimize conflicts. The Fish and Wildlife Service was concerned about bison wintering on the refuge because of (1) increased consumption of supplemental feed and associated costs, (2) conflicts with the elk-feeding program and management guidelines for the refuge, (3) human safety concerns near the refuge visitor center, along the refuge road, and in the town of Jackson when bison approached the refuge's south entrance, and (4) property damage (e.g., fences and signs).

In the 1970s and 1980s bison on private land, or animals that were a threat to human safety or property, were shot. In 1989 the Wyoming legislature authorized a wild bison reduction season.

Bison Numbers: Explosive Population Growth and Further Attempts at Management

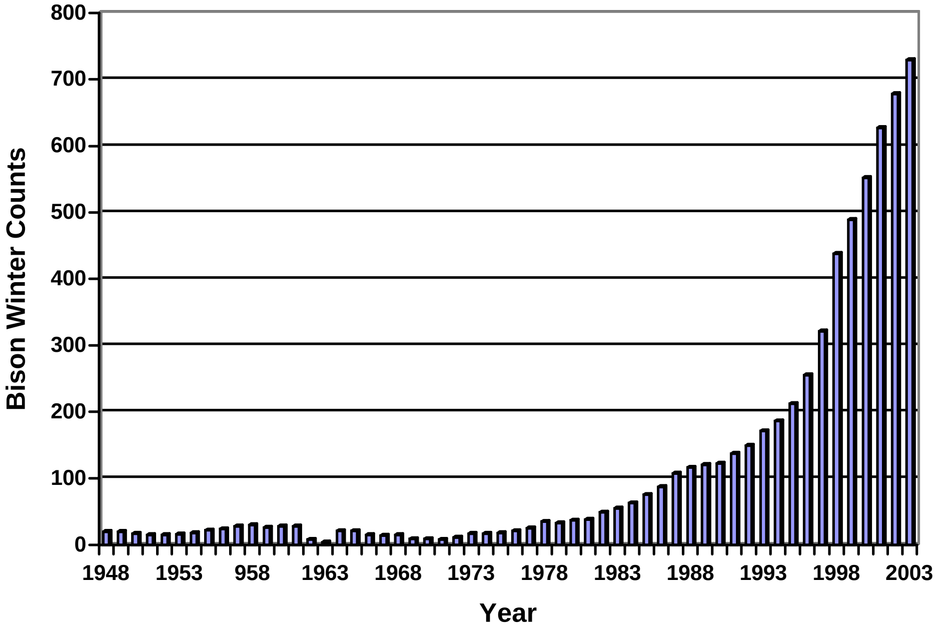
Since discovering the elk feedlines on the refuge in 1980, the bison herd has greatly increased in size (see Figure 3-4), and the U.S. Fish and Wildlife Service has both culled them (taking 16 bison) and conducted a special permit hunt (taking 19 bison) in an effort to reduce it. However, litigation brought hunting to an end on the National Elk Refuge.

Herd reductions have not taken place since 1990 on the National Elk Refuge, and the bison population has continued to grow at a rapid rate, increasing annually by approximately 10%–14%. To slow population growth, the Wyoming Game and Fish Department reinitiated hunting in 1998 outside the National Elk Refuge and Grand Teton National Park, where bison could legally be hunted. Few bison have been killed, however, because the animals are mainly distributed within the park and refuge lands. The annual number of bison harvested ranged from a low of 4 in 1998 to a high of 47 in 2002.

Present Conditions

Bison are counted annually on the refuge in the winter and in the park in the summer. As of February 2004, the herd numbered 729. A study was initiated in 1997 to determine more about bison demography, reproduction, and effects of brucellosis on the population.

FIGURE 3-4: BISON HERD GROWTH SINCE 1948



In 2002 the Wyoming Game and Fish Commission and the Wyoming Livestock Board defined two wild bison management areas, one for the Absaroka herd and the other for the Jackson herd. The state has jurisdiction, over bison from the Jackson wild bison herd in "all lands in Lincoln, Sublette and Teton Counties west of the Continental Divide, excluding Grand Teton National Park, Yellowstone National Park and the National Elk Refuge." The U. S. Fish and Wildlife Service and the National Park Service have jurisdiction over wildlife on the elk refuge and in the park, respectively (16 USC 668dd, 16 USC 1).

HABITAT AND FORAGE

During the summer bison primarily use nonforested areas of grassland and sage-steppe in the park's central valley, including the Snake River bottoms, where open meadows and forest adjoin. Bison may also be found on the forested hills on the eastern edges of the park and the refuge. Most of the herd winters on the refuge, although some use open grasslands, the hills beyond the eastern boundary of the refuge, and the hills and open sage-steppe land east of Elk Ranch. During spring and fall transitional periods bison may be found throughout both summer and winter range. In addition, more bison spend time west of the Snake River in the Potholes region of the park during these seasons (Cain et al. 2001).

Bison are primarily grazers whose diet is composed of grasses, sedges (*Carex* species, which grow in moist areas), some forbs, and rarely shrubs, and appear to need water every day (Cooperrider, Boyd, and Stewart 1986). A dietary study conducted on shortgrass plains in northeastern Colorado noted that bison consumed at least 85% grasses and sedges (Peden et al. 1973). Bison preferred warm-season grasses and added shrubs to their diet when grasses were not available.

DISTRIBUTION AND MOVEMENTS

Radio-telemetry studies have shown that the Jackson bison have very consistent seasonal distributions and movements (GTNP unpubl. data). Most of the herd winters on the National Elk Refuge, where they eat natural forage and, for approximately two months, supplemental alfalfa pellets. After feeding operations are discontinued in late winter or early spring, many of the bison move to the northern end of the National Elk Refuge and the southern end of Grand Teton National Park. Hazing has been used to encourage animals inclined to remain on the refuge to move

Map

Jackson Hole Bison Herd Seasonal Ranges

northward in the spring. During April and May the herd typically is found in the vicinity of the Kelly hayfields, the Hunter-Talbot area, and the Teton Science School, as well as on the northern edge of the refuge. Small areas of Bridger-Teton National Forest near Shadow Mountain and Ditch Creek are also used occasionally. Much of the Kelly hayfields and Hunter-Talbot area is composed of previously cultivated agricultural lands (primarily for the cultivation of smooth brome and alfalfa). Northward migrations through Antelope Flats and the Snake River bottoms to primary summering areas continue during May and June. Because the majority of calving takes place during the transition between winter and summer ranges, births can happen anywhere from the National Elk Refuge to the northern portions of the summer range in Grand Teton National Park (GTNP unpubl. data).

Most of the Jackson bison herd summer in Grand Teton National Park in sagebrush-grassland areas in the Potholes, around Cow Lake, and along the Snake River between Deadman's Bar and Moran, where cottonwood / spruce riparian areas are also used. Occasional movements (usually by bulls) into the lower drainages of Pacific Creek and Pilgrim Creek are also observed. Bison often are found in open grasslands such Elk Ranch Flats and, increasingly as the herd expands in size, in surrounding areas, including Uhl Hill, Wolff Ridge, and the rolling hills to the east of Elk Ranch. In July and August large numbers of bison often congregate along U.S. 287 just south of Moran, where they are a major tourist attraction. Cows, calves, subadult males, and some adult males are quite gregarious throughout the year and rarely stray from well-defined seasonal ranges. Older adult males, however, often become solitary, especially during the summer, and are occasionally observed outside these areas. Periodically adult male bison have been found wandering near Marbleton, Wyoming (one in 1988), and Cora, Wyoming (three in 1990 and two in 1992); it is suspected these bison were from the Jackson herd.

From late August through September bison begin moving south along the same migration routes used during spring. Typically large numbers of bison are present in the Mormon Row-Kelly hayfields / Hunter-Talbot area throughout September and October, with some on the National Elk Refuge during this time. The herd uses all of these areas throughout the fall, and during some years they may remain in the park into November. Generally, most bison move onto the refuge by December, where they subsist on native winter range and forage produced on irrigated fields until supplemental feeding begins, usually in late January.

BEHAVIOR AND SOCIAL INTERACTIONS

Like most species, bison are driven by instincts for survival and mating. Distinct behaviors vary with age and sex. Cow/calf herds, for example, are most pronounced in the spring, during calving. This herding instinct may be motivated primarily to protect calves against predators because adult bison have few natural predators. The social bonds formed by cow/calf herds are strong and usually are broken only by severe environmental conditions.

Young bulls (up to six years of age) often separate from the cow/calf herds after the rut to form small fraternal groups. They generally coexist peacefully with each other for most of the year, but as the rut approaches, increased competition and fights for dominance occur. Older bulls (more than 10 years of age) are often solitary individuals that may move long distances.

Bison are quite sociable, as long as the habitat allows them to aggregate. Large herds of bison of mixed sex and age classes may congregate on range with suitable forage, especially during the rut, but herds seldom spend much time in any one place. Because bison live on large quantities of forage, herds are constantly on the move. They seek out higher quality forage, but those sources are generally available only on a short-term, seasonal basis.

In winter the greater Yellowstone ecosystem is the most severe North American habitat supporting a viable population of free-ranging bison (Meagher 1971).

BREEDING, CALVING, AND AGE AND SEX CLASSES

The breeding season begins in mid-July and peaks during August. Most females breed at 2.5 years of

Bison calf.

age (GTNP unpubl. files). Males, on the other hand, do not usually become part of the active breeding population until they are about 6 years old. Bison males display and fight each other as they compete for access to receptive females. Although younger bulls are capable of siring offspring, larger older bulls are dominant and monopolize females.

Typically, bison are born in the spring. Calving begins by mid-April, but most births occur during May and June, and 95% are completed by the end of July. Sex ratios in the Jackson bison herd have been approximately equal but have slightly favored females over males in most years.

Annual winter classification counts provide information on the age structure of the Jackson bison population. From 1998 through 2004 adults have constituted 64% of the herd, with yearlings at 15%, calves at 19%, and unclassified at 2% (GTNP unpubl. data).

OTHER FACTORS INFLUENCING NUMBERS, DISTRIBUTION, AND HEALTH

AMOUNT, QUALITY, AND AVAILABILITY OF WINTER AND TRANSITIONAL RANGE

Like other species, seasonal availability of suitable habitat profoundly affects the distribution and health of bison. As winter approaches, bison migrate to lower elevations and gradually alter their diets, adding plant species of decreasing palatability and nutritional quality as preferred foods become less available (Leopold 1933; Halfpenny and Ozanne 1989).

The amount, quality, and availability of winter and transitional range depend on temperature and precipitation. Halfpenny and Ozanne (1989) found temperature, snow depth, snow density, duration of winter, and lateness of spring to be critical factors affecting moose survival in Grand Teton National Park. These factors would also be critical for bison, although perhaps to a lesser extent due to bison's ability to move snow aside with their heads to get at vegetation. Farnes (unpubl. data, cited in Farnes, Heydon, and Hansen 1999; NPS and USFWS 1996) noted that the northern range Yellowstone bison and elk during 1968–81, generally foraged in areas with less than 6 inches snow-water equivalent. A snow depth of 1 to 2 inches snow-water equivalent was enough to initiate migration by at least some of the herd.

Snow-water equivalents averaged for areas within the park from 1961 to 1990 reveal few locations with averages below 6 inches (Farnes, Heydon, and Hansen 1999). Although Moosehead Ranch, for instance, had averages of 3.9 to 4.7 and Antelope Flats, 4.3 to 4.7, most park areas had higher averages, making them unsuitable for wintering bison or elk.

DISEASES

Because both elk and bison would be affected by many of the infectious diseases discussed in this document, this topic was covered for both species in the disease section under elk (see the discussion beginning on page 126).

HUNTING

Bison hunting is currently permitted only on federal lands in Bridger-Teton National Forest, state lands, and private lands; these areas constitute only a fraction of the herd's range. From 1997 through December 2003, hunters harvested 161 bison in Bridger-Teton National Forest. There is no legal authority for bison hunting in Grand Teton National Park.

As the bison population has grown, the herd's range has expanded eastward to some extent, and hunting success has improved since 1998.

PREDATION

Predation has not been a significant cause of death in the Jackson bison herd. Even though grizzly bear ranges have expanded in recent years to include the southern portion of Grand Teton National Park, no cases of predation are known in this area. Wolf predation may have caused the death of one marked cow bison near the eastern boundary of the National Elk Refuge, but the actual cause is unknown. Before the carcass was discovered, the cow had been seen in very poor physical condition after having isolated herself from other bison.

Preliminary studies in Yellowstone indicate that some wolves are preying on bison (D. W. Smith, Murphy, and Guernsey 1999) although the level is not significant. Smith and others suggest that for some wolves, Yellowstone bison may become a regular prey item, particularly during late winter and spring.

SUMMARY OF OTHER CAUSES OF MORTALITY

Known mortality averaged 6% from 1997 through 2003. Of 257 deaths documented from 1997 through 2003, hunter harvest accounted for the greatest number (164), but the cause of many deaths (37) was unknown. Vehicle collisions killed 26, and natural causes were responsible for 18 deaths. Wolf predation may have caused the death of one marked cow, but the actual cause is unknown.

Mortality in the sub-sample of female bison studied from 1997 to 2003 and monitored through radio-telemetry averaged 7%, including harvest (5% excluding harvest deaths; methods from Heisey and Fuller 1985). The total number of known deaths (13) was small; 4 were killed by hunters, 1 was killed by a vehicle, and 8 died of natural causes. Annual survival rates were high (95% without harvest mortality and 93% with it).

Winter-kill is the primary cause of mortality for bison in Yellowstone National Park, where bison are not artificially fed in winter. Winter-kill results from the combined effects of climatic stress, low forage availability, and declining physiological condition of individual animals. Bison expend most of their body fat in early to midwinter. As winter progresses, some bison cannot acquire enough of the nutrients needed to survive the remainder of the season. The old, sick, and young generally are the first to die during the winter, and relatively few members of the Yellowstone National Park population reach "old age," e.g. 12 to 15 years (Fuller 1959).

In contrast, there are few examples of obvious winter-kills in the Jackson population. Although winters can be severe in the southern greater Yellowstone ecosystem, Jackson bison follow the terrain south from Grand Teton National Park to the National Elk Refuge, where there is less snow. Milder climatic conditions, plus supplemental feeding on the refuge, make them better able to fend off the stresses caused by winter.

GENETICS

Genetic variability allows populations to evolve under different selection pressures and is influenced by population size and composition as well as random events (Berger and Cunningham 1994). If a population is not genetically variable, it may not be able to survive changing environmental conditions. Populations that have decreased levels of genetic variation may also suffer from inbreeding effects. To avoid these effects over a long time, Frankel and Soulé (1981) suggested that the estimated size of a minimum viable population should not allow greater than 1% loss of the genetic variation per generation. However, not all populations with low genetic diversity are suffering inbreeding effects. For instance, there is no evidence of inbreeding effects in black-tailed prairie dogs or black bears, despite low levels of genetic variation in some populations (Hoogland 1992; Paetkau and Strobeck 1994).

Studies indicate that a large proportion of genetic variability in North American bison may already have been lost (Berger and Cunningham 1994). When the bison were driven to near extinction in the late 19th century, bison experienced an extremely large "bottleneck" (Roe 1970), where the genetic material that had been in an entire species of millions was now narrowed to only that in the remaining 300 individuals. While it is presumed this also significantly lowered the species' genetic variability, it is unknown whether this is the case since genetic material from the larger herd was never taken. In fact, other large mammal species in northern temperate regions that have not gone through a large human-induced bottleneck also have low genetic variability (Sage and Wolff 1986).

To prevent the Jackson bison herd from experiencing "genetic drift," or the loss of genetic variation because the population is small, it has been suggested that 1–10 migrants per generation be added to an otherwise closed population. Because the Jackson and Yellowstone herds contain no cattle DNA as a result of private-sector crossbreeding, any addition of new bison to the herd would need to be carefully screened.

An additional genetic issue concerning bison is the extent to which the natural-resistance-associated-macrophage-protein-l gene (NRAMP1, now known as SLC11A1 [Derr et al. 2002]), is prevalent in the bison herd. This gene has been shown to have a major impact on controlling a natural resistance to brucellosis in bovines, including cattle. It also appears that the DNA sequence of NRAIVIP1, which appears to confer natural resistance to brucellosis, has been partially conserved in native bison. Although the extent to which these genetic traits are expressed in Jackson Hole bison is not fully understood, conserving them is an important consideration for long-term brucellosis management.

Estimating a minimum viable population for bison requires accounting for selective pressures on the population. These pressures include the influences of sex ratio on breeding adults, the reproductive success of males and females, and population fluctuations. In addition to genetic factors, the minimum viable population is also affected by demographic and environmental randomness and catastrophes. How these factors affect different taxa depends on their respective ecology and life history traits, so there is no uniform estimate of a minimum viable population. However, management prescriptions that result in nonrandom selective removal of bison from the population through lethal and nonlethal mechanisms (for example, selective removal of pregnant females, females that carry the NRAMP1 trait, or prime breeding-age bulls) can negatively influence the genetic integrity and viability of a population. For the purposes of analysis, it was assumed that genetic viability would be threatened if the bison herd dropped below 400 animals and effective population size decreased below 100 (Berger 1996).

OTHER WILDLIFE

The categories of species most likely to be affected by bison and elk management are (1) other ungulates, in terms of competition for food, habitat changes, and potential for disease transmission, (2) predators and scavengers, in terms of their food base, potential for disease transmission, and vaccine safety issues, and (3) other species that could be affected by changes in habitat (e.g., Neotropical migratory birds). Altogether 48 native species of mammals inhabit the National Elk Refuge, while 61 occur in Grand Teton National Park, plus one exotic species, the mountain goat.

THREATENED, ENDANGERED, AND SPECIAL CONCERN SPECIES

The U. S. Fish and Wildlife Service is directed by the Endangered Species Act to identify and protect threatened or endangered animal and plant species. The U. S. Forest Service has adopted policies to ensure that no agency actions result in the need to list sensitive species as threatened or endangered, and the state of Wyoming has identified species of special concern that are considered high priorities for conservation attention. These species are identified in the following discussion.

Bison and elk management on the National Elk Refuge and in Grand Teton National Park has the potential to affect endangered, threatened, and special concern species both directly and indirectly. Indirect effects include disturbance caused by shooting and hazing bison and elk, the alteration of habitat used or potentially used by threatened or endangered plants or wildlife, the introduction of disease agents into the environment through vaccination of bison and elk, and changes in numbers and distribution of bison and elk, which serve as live prey or carrion for threatened or endangered animals.

NPS policy requires that impacts on state and locally listed species also be considered. Species of special concern are defined as those species for which data are sufficient to document that the species is in decline, or a species that because of its unique or highly localized habitat requirements warrants special management. Species of special concern do not receive the same degree of protection as endangered or threatened species, although decreasing numbers or loss of habitat makes them of concern to federal land management agencies.

As previously explained, the following species would not be affected by any of the alternatives considered in this document, and they are not discussed further: lynx, wolverines, river otters, fishers, American martens, and whooping cranes.

GRAY WOLF

Gray wolves *(Canis lupus)* were deliberately exterminated from the greater Yellowstone ecosystem by the 1930s and were placed on the endangered species list in 1973. After years of scientific research and public debate, 66 gray wolves from Canada were reintroduced into the Yellowstone area (31 wolves) and central Idaho (35 wolves) in 1995 and 1996 (USFWS et al. 2003). They were classified as a nonessential, experimental population in accordance with the Endangered Species Act. This means that the species is treated either as proposed for listing in a national forest or as threatened in a national park or a national wildlife refuge (50 CFR 17). This nonessential, experimental population designation allows federal, state, and tribal agencies and private citizens more flexibility in managing the wolf population.

Wolves began dispersing from Yellowstone National Park to Grand Teton National Park in 1997. The Teton pack and the Gros Ventre pack ranged widely throughout the park during the winter of 1998–1999. Both packs and the Soda Butte pack (now called the Yellowstone Delta pack) used the Pacific Creek drainage as a corridor between Yellowstone and Grand Teton. The Teton pack moved much less than the other two packs, remaining primarily in the northeastern part of the park, where they denned in the spring of 1999 and produced pups. They or their descendants have denned in the northeastern part of the park every year since except for 2000. The Teton pack currently has 16–18 members, and the pack's home range encompasses the northeastern corner of Grand Teton National Park and extends into the Gros Ventre River drainage. The Soda Butte (or Delta) pack returned to Yellowstone National Park and has since remained primarily inside that park. The Gros Ventre pack denned in the Gros Ventre River drainage outside Grand Teton, but did not den or produce pups in 2003 or 2004. The Gros Ventre pack ranged throughout the Gros Ventre River drainage, overlapping with the home range of the Teton pack near the three WGFD feedgrounds. The entire Gros Ventre pack was killed by government authorities in 2004 after preying on livestock (Jimenez, pers. comm. 2004). Wolf packs and individuals within packs typically fluctuate over time, particularly when expanding into unoccupied habitats.

The National Elk Refuge was visited from time to time by the Gros Ventre pack and since January 2003 by the Teton pack. Wolves on the refuge have generally been a rare sight except for the winter of 1998–99, when the Gros Ventre and the Soda Butte packs hunted on the refuge for two months. Since 1999 the Gros Ventre and the Teton packs have routinely hunted in the Gros Ventre drainage, including the WGFD feedgrounds. In January 2003, for the first time since their arrival in the valley, five members of the Teton pack were observed on the refuge. This visit occurred shortly after 17 wolves from a Yellowstone pack were spotted in the northern part of the refuge. Neither pack remained on the refuge for more than a few days. The following winter (2003–4) four wolves spent most of the season on the northern end of the refuge, and in the winter of 2004–5 three wolves appeared to be residing on the refuge. One of these canids has been identified as a dispersing wolf from the Druid Peak pack in Yellowstone.

Recent winter studies in and adjacent to Yellowstone have documented that elk comprise more than 85% of wolf kills, followed by bison, moose, deer, and pronghorn (USFWS et al. 2003; Jaffe 2001; Mech et al. 2001). Elk are also the preferred prey of wolves in Jackson Hole during all seasons of the year (B. Smith, pers. comm. 2002). However, WGFD personnel have stated that to date wolves have not had a substantial impact on the Jackson elk herd (WGFD 2003). Studies from November to March on the northern range of Yellowstone National Park documented a three-year average kill rate of 1.8 animals per wolf per 30-day study period, with elk comprising 90% of the kills (USFWS et al. 2003). Reestablishing and expanding wolf populations characteristically have higher kill rates than most wolf / ungulate systems (Jaffe 2001). These figures should not be used to estimate annual kill rates for the greater Yellowstone wolf populations because kill rates in winter do not necessarily reflect kill rates during other times of the year when prey are less stressed by weather conditions and forage is plentiful. Kill rates of wolves in summer have not been studied in any ecosystem (WGFD 2003).

Grizzly Bears

Grizzly bears *(Ursus arctos horribilis)* in the lower 48 states were listed as threatened in 1975. In the 1980s a recovery plan was developed, and in recent years their numbers have increased to the point that delisting is expected in the near future. Grizzly bears occur in the park, but they have not been sighted in the refuge since 1994. The ecosystem's grizzly bears number an estimated 400–600, and their distribution has been increasing over the past two decades. They widely use the northern two-thirds of Grand Teton National Park, but can occur throughout the park and surrounding areas.

Grizzly bears are omnivores that feed on nutritious succulent vegetation, grubs, insects, fish, newborn ungulates, and carrion. In Yellowstone National Park from March through May, ungulate carrion (mostly elk and bison) is an important food source (Mattson 1997). This is not currently the case in Grand Teton National Park. Elk and bison in the Jackson herds have a low winter mortality rate due to the supplemental feeding program on the National Elk Refuge and in the Gros Ventre Range. Grizzly bears in Grand Teton National Park do not appear to depend as heavily on meat in the early spring compared to grizzlies to the north in Yellowstone National Park.

By mid-May grizzly bears begin preying on newborn elk calves (Singer et al. 1997; Gunther and Renkin 1990). Even though grizzly predation on elk calves has not been documented in Grand Teton National Park, it likely occurs.

Grizzly bears dominate other scavengers at carcasses (Servheen and Knight 1990), but many carcasses are consumed prior to being found by a bear (Green 1994). Individual bears are most likely to get their largest meals from adult moose and elk that are prey and from adult female bison that are scavenged (Mattson 1997).

BALD EAGLES

The bald eagle is currently listed as federally threatened and is protected under the Migratory Bird Treaty Act (16 USC703) and the Bald Eagle Protection Act (16 USC 668). It is also a Wyoming priority 2 species of special concern. Bald eagle winter habitat is generally associated with areas of open water, where fish or waterfowl congregate (Swensen, Alt, and Eng 1986), or ungulate winter range where eagles scavenge on carcasses of large mammals. The majority of nesting territories in Jackson Hole are along major rivers or lakes within 3 miles of their inlets or outlets, or along thermally influenced streams or lakes. Nearby food, suitable perches, and security from human activities are important habitat components for both nest and roost sites.

Two bald eagle nesting territories occur on or near the National Elk Refuge. During the fall as many as 35 bald eagles have been seen at one time in the cottonwood trees near the southern boundary for the elk hunt area on the refuge (Griffin, pers. comm. 2002). These eagles feed on gut piles left by hunters. Typically only five bald eagles remain on or near the refuge throughout the winter.

Grand Teton National Park contains 12 known nesting territories and pairs; however, not all pairs nest in the park each year. Known territories are along the shorelines of the Snake River and Jackson Lake. No bald eagles are known to nest within the John D. Rockefeller, Jr., Memorial Parkway, although the upper Snake River is used extensively for foraging year-round (Alt 1980). Bald eagles that nest along the Snake River in Grand Teton National Park may remain in their nest territories throughout the year, occasionally leaving during the nonbreeding season to exploit abundant or ephemeral food sources elsewhere. Lake-nesting birds may remain in their territories for most of the time that Jackson Lake is free of ice. Other winter foraging areas in Grand Teton National Park include the Buffalo Fork and Cottonwood Creek.

In 2004 bald eagles occupied 11 of 12 established nesting territories in Grand Teton National Park. Ten of these nests were active, and five nests successfully produced a total of six fledglings (NPS 2005a). The nest that is adjacent to the National Elk Refuge produced one fledging in 2004.

YELLOW-BILLED CUCKOO

In 2001 the U.S. Fish and Wildlife Service determined that the yellow-billed cuckoo (*Coccyzus americanus*) population in the western United States meets the criteria to qualify as a distinct population segment and is consequently warranted protection under the Endangered Species Act. However, the agency's current workload precludes listing at this time.

The yellow-billed cuckoo is a Neotropical migratory bird that historically was distributed throughout most of the United States, southern Canada, and northern Mexico. The cuckoo's population is highly fragmented and at dangerously low levels. It is considered a rare summer resident of Wyoming. Little is known about the historic distribution of cuckoos in Wyoming, and documented observations have been few. However, Wyoming is on the periphery of the cuckoo's range, and the species may never have been abundant in Wyoming due to its breeding requirement for relatively large tracts of woody riparian habitat below 7,000 feet (Wyoming Natural Diversity Database 2002). Yellow-billed cuckoos rarely occur in Jackson Hole, and there is no documentation of nesting (Wachob, pers. comm. 2004). A few were seen at Toppings Meadow west of Mount Leidy in the 1970s and near the Gros Ventre campground about 15 years ago during breeding bird censuses (Raynes, pers. comm. 2002). The last documented sighting was in 2000 when one was caught in a mist net near Ditch Creek in Grand Teton National Park (Wachob, pers. comm. 2004).

The loss of woody riparian habitat on the National Elk Refuge and the loss of dense understory vegetation in Grand Teton National Park and Bridger-Teton National Forest due to heavy browsing by ungulates and other factors could be contributing to the decline of yellow-billed cuckoos.

OTHER UNGULATES

The greater Yellowstone ecosystem supports large migratory herds of numerous ungulates due to its climate, geology, elevational and vegetational diversity, and relatively undeveloped state. In addition to bison and elk, pronghorn, mule deer, bighorn sheep, and moose occur within the primary analysis area. As previously discussed, white-tailed deer are not abundant, and nonnative mountain goats have little habitat overlap with bison and elk, so impacts on these species are not analyzed.

In the greater Yellowstone ecosystem, as in most areas, winter is the critical period for ungulates. Snow depth and density limit the amount of range accessible for use (Gilbert, Wallmo, and Gill 1970). The severity of the winters also makes ungulates more vulnerable to other stresses. Unfamiliar human activity on winter range can be extremely draining on energy reserves compared to predictable and habitual activities, or to disturbances occurring during other seasons.

BIGHORN SHEEP

In Grand Teton National Park bighorn sheep are found in isolated bands at high elevations along the western park boundary and among the major peaks. The Teton bighorn sheep herd is nonmigratory and is composed of two subpopulations: one in the north (west of Jackson Lake), and one in the south (west of Phelps Lake). The entire herd is a marginally viable, remnant population that is geographically isolated from other herds and persists in a harsh environment. There may be limited interchange between the two subpopulations, which together number about 125 (Wolff, pers. comm. 2004).

Bighorn sheep on the National Elk Refuge.

Bighorn sheep on the National Elk Refuge are primarily winter residents that migrate from the Gros Ventre Mountains. From November to April, they occur on the eastern slopes of Miller Butte, along the eastern side, and in the northern portions of the National Elk Refuge in the vicinity of Curtis Canyon. As many as 55 sheep have been observed during previous winters on the National Elk Refuge (NER files).

On the National Elk Refuge and in Grand Teton National Park the diet of bighorn sheep may overlap that of elk and bison, but habitats overlap in relatively few areas. Competition with elk and bison is limited under existing management (B. Smith, pers. comm. 2002).

PRONGHORN

In the past as many as 450 pronghorn summered on Jackson Hole lands (including the National Elk Refuge, Grand Teton National Park, and Bridger-Teton National Forest). For unknown reasons, the number of pronghorn has recently declined to approximately 175 (Berger, pers. comm. 2002). Most pronghorn migrate south out of the valley through the Gros Ventre Mountains to winter range in the Green River basin. Small numbers of pronghorn (up to 15 in some years) reside on the northern part of the refuge in the mixed sagebrush and grassland communities. Occasionally, as many as 33 pronghorn have wintered on the refuge and the adjacent slopes of East Gros Ventre Butte. Harsh winter conditions common to the valley, as well as predation by coyotes, have significantly reduced the number of animals surviving the winter. In Grand Teton National Park pronghorn inhabit the flat grasslands and sagebrush-steppe communities extending from Moran south to the National Elk Refuge during summer months.

Because most pronghorn migrate out of the valley in winter, they are not sympatric with elk and bison on winter range. During summer, elk and bison occupy the same habitats as pronghorn in Grand Teton National Park. Pronghorn may benefit from the presence of elk and bison in the summer because grazing by the larger ungulates may keep grasses from outcompeting the more preferred forbs and shrubs (Berger, pers. comm. 2002).

MULE DEER

Mule deer in Jackson Hole belong to the Sublette deer herd, whose estimated population was 32,000 in 2004 (Clause, pers. comm. 2004). The Sublette deer herd ranges from the Wind River Mountains north to the Gros Ventre Range, west to the Wyoming Range, southwest to the Green River drainage, and southeast to the Little Colorado Desert. A small proportion of these deer come into the Jackson Hole area, and they are not counted separately from the Sublette herd as a whole. Some mule deer winter in Jackson Hole and can often be seen in the town of Jackson and on East Gros Ventre Butte.

On the National Elk Refuge mule deer winter primarily on Miller Butte, but their numbers have greatly declined since the refuge closed an old feed shed that allowed deer access to alfalfa pellets. No deer were seen on Miller Butte during the 2001–2, 2002–3, or 2003–4 winters. In spring, summer, and fall a small number of mule deer can be found on the northern part of the refuge in the Gros Ventre Hills and along the Gros Ventre River. These deer may leave this area at the beginning of elk hunting season in October. In Grand Teton National Park deer are relatively common.

MOOSE

Experts disagree about the exact number of moose in the Jackson Hole area but most believe it is about half of what it was at its peak in 1992, when it numbered approximately 3,500 (Brimeyer, pers. comm. 2003). Moose range includes the National Elk Refuge, Grand Teton National Park, and Bridger-Teton National Forest. In the past 20 to 30 years moose used riparian habitat along the Gros Ventre River on the refuge during the winter.

In Grand Teton National Park moose can be found at higher elevations in the summer and in riparian areas throughout the year. In the winter moose are often seen in sagebrush-steppe habitat in Antelope Flats, along the Snake and Gros Ventre River corridors, and in the Willow Flats / Hermitage Point area. The parkwide population during summer is unknown, but most moose that summer within the park probably remain for the winter (NPS 1995).

Both moose and elk browse on willow and aspen and other woody shrubs. Bison do not typically browse on woody vegetation (except near feedgrounds), but they rub against trees and seek shelter in riparian areas. The decrease in woody vegetation due to large numbers of elk on the refuge likely has had a negative effect on moose on the refuge over the long term.

PREDATORS AND SCAVENGERS

COYOTES

Coyotes are plentiful in the greater Yellowstone ecosystem, including the National Elk Refuge, Grand Teton National Park, and Bridger-Teton National Forest. Several family groups live year-round on the refuge, but they increase to nearly 100 as "transients" follow the elk herds to the refuge in the winter (Camenzind, pers. comm. 2003). Coyotes also occur year-round in all areas of Grand Teton National Park. Coyotes are opportunistic predators that readily feed on carrion, but they also catch a variety of small mammals from mice, squirrels, and rabbits to fawns and calves. They also feed on insects and fruit. In winter elk and occasionally bison carrion on the refuge are an important part of their diet. In the spring coyotes may take elk calves during the first month of life. They rarely have the opportunity to kill bison calves due to the presence of the herd and protective mothers.

COUGARS

Cougars occur throughout the greater Yellowstone ecosystem, including the refuge, the park, and the national forest. Cougars feed mainly on ungulates, primarily deer, throughout much of their distribution, but they can take elk, moose, and bighorn sheep. Where elk are abundant, they can become a large part of the cougar diet (Ruth 2004). They have also been known to feed on wild horses, beavers, porcupines, raccoons, and hares opportunistically, indicating one of the most varied diets of any predator in the Western Hemisphere (Hansen 1992). A cougar (also known as a mountain lion or puma) and her three kittens were seen frequenting a cave on

Miller Butte on the refuge for two months during the winter of 1999. She was a skilled elk and deer hunter and provided a great wildlife watching opportunity.

Cougars prey mostly on a combination of deer and elk in the Jackson Hole area, relying more on elk than in other areas of the country due to the large elk herd (Moody, pers. comm. 2002; Quigley, Craighead, and Jaffe 2005). The Teton Cougar Project* was initiated in January 2001 and is focusing field investigations on cougar predation. Information collected to date show that elk make up approximately 80% of 86 cougar kills from 2000 to 2004 (Quigley, Craighead, and Jaffe 2005). Although it is apparent that elk are a major prey species in Jackson Hole, a larger sample size is needed to draw statistically valid conclusions (Gray, pers. comm. 2002; Quigley pers comm. 2005). Cougar research in Jackson Hole will continue until 2007 under the auspices of Beringia South.

The exact number of cougars in the analysis area will never be known. For the purposes of this environmental impact statement, the Teton Cougar Project estimated 28 resident adult cougars based on an examination of the home ranges of radio-marked cougars in the Buffalo Valley and the lower Gros Ventre drainages, the home ranges of known or suspected unmarked residents, and the quality of habitat in the balance of the analysis area as compared to the Buffalo Valley and the lower Gros Ventre. Project personnel will conduct a more quantifiable estimate at the end of 2005 or the beginning of 2006.

BLACK BEARS

Black bears are common in Grand Teton National Park and Bridger-Teton National Forest, but rarely occur on the National Elk Refuge. They are omnivores that inhabit forested areas, feeding on nutritious, succulent vegetation and on grubs, fish, newborn ungulates, and carrion. Elk and bison carrion may occasionally provide valuable protein. Black bears are known to successfully prey on elk calves. Smith and Anderson (1996) reported that 22 of 145 radio-collared calves died before July 15 from 1990 to 1992; black bears were responsible for 11 of these mortalities. During the late 1990s black bears were responsible for 16 of 42 calf deaths (B. Smith, pers. comm. 2003). In a north-central Idaho study, black bears killed 38 of 53 marked calves or 72% (Schlegel 1976). Bison calves are not usually vulnerable to black bears because bison cows can adequately defend their young. While black bear numbers are unknown, their population is considered stable.

OTHER MAMMALIAN PREDATORS AND SCAVENGERS

Other mammalian predators inhabiting the project area include badgers, mink, long-tailed weasels, red foxes, skunks, and bobcats. All of these species prey on small mammals. A few may opportunistically feed on elk or bison carrion, but they do not depend on it as a food source. Mink are not known to feed on elk or bison carrion. Bobcats may take an occasional elk calf, but calf-mortality studies indicate that this is not a significant cause of mortality (Smith and Anderson 1996).

AVIAN PREDATORS AND SCAVENGERS

Golden eagles, peregrine falcons, prairie falcons, red-tailed hawks, Swainson's hawks, American kestrels, rough-legged hawks, and other raptors are resident species in Jackson Hole. Eagles and hawks are all predators, but their preferred prey varies widely. Small hawks feed typically on insects, while larger hawks feed on birds and small mammals. Eagles may take prey as large as foxes. Falcons often specialize on birds but may also take rodents and insects. Some of these raptors feed opportunistically on carrion, especially in winter.

Black-billed magpies and common ravens are omnivores that eat a wide variety of insects, rodents, lizards, and frogs, as well as eggs and hatchlings of other birds. They often feed as scavengers on carrion and human garbage. Elk carrion is an important source of food in the winter for avian scavengers on the refuge.

SMALL MAMMALS

Small mammal species in the Jackson Hole area are abundant and include ground squirrels, mice, voles, shrews, chipmunks, tree squirrels, muskrats,

* Originally operated by the Wildlife Conservation Society and now operated by Beringia South.

northern pocket gophers, pikas, cottontails, and snowshoe hares. The most important factor influencing the distribution and abundance of small mammal populations is suitable habitat. Many small mammals occupy a wide variety of habitats, while others have specific habitat requirements and are, therefore, limited in their distribution (see Table 3-10). In general, most species tend to prefer more mesic environments. Habitat edges also tend to support more species than interior habitats.

TABLE 3-10: SMALL MAMMALS THAT OCCUR IN NATIVE GRASSLAND / CULTIVATED FIELDS, SAGEBRUSH SHRUBLAND, AND RIPARIAN AND ASPEN WOODLAND HABITATS

Native Grasslands/Cultivated Fields — Northern pocket gopher, desert cottontail, Wyoming ground squirrel, Merriam's shrew, long-tailed vole, deer mouse, Uinta ground squirrel, yellow pine chipmunk, sagebrush vole
Sagebrush Shrublands — Northern pocket gopher, Wyoming ground squirrel, least chipmunk, desert cottontail, yellow pine chipmunk, masked shrew, dusky shrew, Merriam's shrew, meadow vole, montane vole, deer mouse, sagebrush vole, Uinta ground squirrel, long-tailed vole, mountain (Nuttall's) cottontail, heather vole
Riparian and Aspen Woodlands — long-tailed vole, montane vole, meadow vole, water vole, desert cottontail, snowshoe hare, mountain cottontail, northern pocket gopher, Wyoming ground squirrel, Uinta ground squirrel (aspen), yellow pine chipmunk, masked shrew, golden-mantled ground squirrel, Uinta chipmunk, red squirrel, northern flying squirrel, southern red-backed vole, western jumping mouse, vagrant shrew, dusky shrew, water shrew, heather vole, deer mouse, muskrat

SOURCE: Based on the University of Wyoming, Geographic Information Science Center, *Species Atlas,* 2003.

Small mammals depend on grasses for forage, as well as for cover from predators. Overgrazing by large numbers of elk and bison could limit the numbers of rodents that can survive in sagebrush and grassland habitats.

Riparian and aspen zones typically support a greater abundance of small mammals and a greater diversity of species, although many of these species can be found in other habitats. Browsing by elk and bison has greatly altered some small mammal habitats on the National Elk Refuge, which likely has changed the type of species found in affected areas.

A small mammal study conducted on the National Elk Refuge in the summers of 2000 and 2001 identified three species inhabiting cultivated fields — deer mice, voles, shrews, and shorttail weasels (Swanekamp, pers. comm. 2002).

Grazing by elk and bison reduces residual cover that would otherwise be available to small mammals. Irrigation, especially flood irrigation, designed to increase elk forage, also negatively affects small mammals by flooding burrows. Elk and bison are probably not affected by small mammal populations. However, large numbers of elk and bison, along with management activities designed to produce more forage for elk and bison, could decrease rodent populations, which would adversely affect avian and mammalian predators.

LARGE RODENTS

Large rodents that occur in Jackson Hole are yellow-bellied marmots, porcupines, and beavers. Marmots occupy rocky slopes of upper elevations, living in burrows in open areas and eating a variety of green vegetation. Porcupines inhabit wooded areas, feeding on leaves, twigs, and green plants during the summer. In the winter they subsist by chewing through the rough outer bark of trees to feed on the inner bark. Beavers inhabit rivers, streams, marshes, lakes, and ponds. They feed on green plants and the bark of certain hardwoods, such as aspen and willow.

Beavers are common in woody riparian areas that provide suitable habitat. Historically, beavers occurred on the southern end of the refuge, but as willow habitat along Flat Creek declined in acreage and condition, beavers disappeared. Currently, beavers that have dispersed from the park or national forest occasionally occur in ponds on the northern part of the refuge.

Porcupines are common, occurring in riparian and aspen woodland communities. They are less common on the refuge, but are occasionally seen in upland shrub communities and riparian and aspen woodland habitats.

Bison and elk probably do not affect marmots, but the decline of woody vegetation on the National Elk Refuge due to browsing by elk and bison has likely reduced the amount of habitat available for porcupines and beavers.

BIRDS

More than 300 species of birds have been observed in Grand Teton National Park and approximately 175 species on the National Elk Refuge.

NEOTROPICAL MIGRATORY BIRDS

Of particular interest to this planning process are Neotropical migratory birds, which breed in North America and spend their winters in the tropics. Throughout their range, these migrants have been experiencing population declines (USGS 1999; Terborgh 1989). Habitat fragmentation and degradation, as well as destruction of winter range, are at least three factors believed to be responsible for these declines (Dobkin and Wilcox 1986; Dobkin 1994; Martin and Finch 1995; George and Dobkin 2002).

Many species of Neotropical migratory birds are declining in North America due to an inability to raise young successfully rather than due to mortality of adult birds (Herkert et al. 1993). Loss of habitat has long been suspected as contributing to nest failure and poor survival of young birds, but habitat fragmentation plays an important role (Kaufmann 1996). In fragmented landscapes, Neotropical species suffer high rates of nest predation by mammals and birds, and also high rates of nest parasitism by brown-headed cowbirds. Researchers have shown that habitat size, shape, and amount and type of edge can all affect breeding success. Edge habitats also support a larger variety and higher density of predators (Lompart, Riley, and Fieldhouse 1997).

Potential nest predators, such as foxes, raccoons, skunks, cats, magpies, crows, and ravens are attracted to habitat edges, often preying on eggs and young birds in small woodlots, narrow strips of riparian habitat, and near edges of larger forests (Wilcove 1985; Yahner 1988). In some forests this edge-enhanced nest predation has been documented to extend more than 300 feet into the interior of the forest patch (Wilcove 1985). Martin (1988, 1993) found that nest predation can account for, on average, 80% of nesting failures, and Donovan et al. (1997) established that where habitats are fragmented, predators gain greater access to nests at forest edges.

Brown-headed cowbirds are common in Jackson Hole, and cowbird parasitism can be a serious problem for many Neotropical migratory bird species. Cowbirds lay their eggs in the nests of other birds, often removing a host egg before laying one of their own. Cowbird chicks hatch earlier and grow faster than host chicks, which results in the cowbird young receiving most of the food and parental care from the foster parents. Female brown-headed cowbirds prefer edge habitats and can lay up to 77 eggs in a single season (Jackson and Roby 1992). Edge-tolerant songbird species can often recognize cowbird eggs and remove them from the nest, or they may abandon parasitized nests. These edge-tolerant species are often permanent residents or short-distance migrants and can nest several times in a season. This increases their chances of raising a successful brood since cowbirds rarely parasitize late season nests (Ehrlich, Dobkin, and Wheye 1988). In contrast, interior forest birds, which are usually long-distance migrants and only nest once or twice a year, often fail to raise any young of their own when forced to nest in edge habitats because they have not evolved behaviors to cope with nest parasitism. As a result, interior forest species, such as the veery and the American redstart, disappear from small patches of forest habitat, and edge-tolerant species such as the American robin and house wren, greatly increase (Herkert et al. 1993).

On the National Elk Refuge small or narrow patches of riparian and aspen woodland habitats are often in poor condition due to overbrowsing by ungulates. However, even if these patches are protected in some manner resulting in improved condition, Neotropical migratory birds may not benefit because of the size and shape of the individual patches for the reasons discussed above. In order to both improve condition of the plant community and benefit the survival and reproduction of Neotropical migratory birds, care must be taken to ensure that preserved habitats are large enough to prevent the habitat patch from becoming a population sink.

An example of a narrow habitat patch would be the cottonwood community along upper Flat Creek. This long riparian strip may always be too narrow to provide forest interior habitat for Neotropical migratory birds that require forest interior conditions for successful nesting. Some species of birds may avoid such areas and not attempt to nest, while others may make unsuccessful nesting attempts. For those birds that attempt nesting but fail to fledge young due to high predation and parasitism rates, this area may become (or possibly has always been) a population sink. Nevertheless, small or narrow tracts of riparian and aspen woodland habitat are still valuable to a variety of birds as stopover sites during migration.

Sagebrush Shrublands and Native Grasslands

Sagebrush and grassland plant communities provide important breeding habitat between May and mid-July to some Neotropical migrant species, and these cover types are abundant on the refuge and in the park.

Typical bird species that nest in the sagebrush shrublands community are sage thrashers, Brewer's sparrows, and sage sparrows. Many sagebrush bird species are declining as habitat throughout the west is converted to farmland and development. As aspen and riparian habitats on the National Elk Refuge are converted to sagebrush habitat due to heavy elk and bison browsing, more sagebrush shrubland habitat will become available to bird species dependent on this habitat. Efforts to restore cultivated areas to native sagebrush communities on the refuge and in the national park would also benefit sagebrush-dependent bird species.

Riparian and Aspen Woodlands

In the arid West riparian and aspen woodland habitats with a shrub understory support the most species-rich communities of breeding birds (Dobkin and Wilcox 1986; Knopf et al. 1988; Saab et al. 1995; Mitton and Grant 1996; Tewksbury et al. 2002), provide critical migration habitat for migratory landbirds (Dobkin 1994), and are centers for biological diversity (Brussard, Charlet, and Dobkin 1998). These habitats are critical for breeding habitat and migration stopovers for 80% of migratory bird species (Krueper 1992) because they are used extensively for feeding, nesting, shelter, and travel corridors. The open canopies allow sunlight to reach the ground, producing a rich understory of shrub and herbaceous species offering structural diversity. The layered structure of these woodlands provides numerous niches for birds. Cavity nesters use snags for nest sites, while predatory birds perch on dead trees to scan for prey. Neotropical birds nest at different levels, and they feed on the diversity of insects found in aspen and riparian woodlands.

The ecological health of a woody plant community can be directly measured by avian species composition, relative abundances, and breeding success (Dobkin, Singer, and Platts 2002). Riparian and aspen woodlands shelter many bird species that have relatively narrow breeding-habitat requirements. These species may occur chiefly or exclusively in these willow, aspen, and cottonwood communities. In the southern portion of the greater Yellowstone ecosystem an ecologically intact riparian or aspen woodland can have 76 species of birds closely associated with it during the nesting season, and 23 "core" species will be common and relatively abundant (Dobkin, Singer, and Platts 2002). All of these 23 core species are Neotropical migrants.

Cattle and wildlife grazing and browsing, especially in arid systems, can greatly affect the quality of riparian habitat for Neotropical migrants (Roath and Krueger 1982; Taylor 1986; Saab et al. 1995; Ammon and Stacey 1997). Upland aspen has been declining in Jackson Hole for the last several decades (Loope and Gruell 1973), as well as throughout the West (Kay 1998). Fire suppression is a major factor in the reduction of aspen (Loope and Gruell 1973; White, Olmstead, and Kay 1998; Kay 1998), but on the National Elk Refuge ungulate browsing has greatly accelerated this decline (Anderson 2002; Dieni et al. 2000).

The mixture of riparian and upland aspen habitats found on the National Elk Refuge and in Grand Teton National Park is important to a variety of species. Wallen (pers. comm. 1994, as cited in USFWS 1998) found that riparian and wetland habitats in Grand Teton generally contain the highest density of Neotropical migrants. Anderson (2002) observed 25 bird species in riparian woodland habitats and 54 species in upland aspen habitat in the Jackson Hole vicinity.

Riparian and aspen woodlands that lack recruitment, such as those found on the National Elk Refuge, are structurally simplified and support a less diverse community of bird species. Birds found in this simplified habitat generally have habitat requirements that can be met in a wide variety of habitat types. Trabold and Smith (2001) found that European starlings on the National Elk Refuge overwhelmingly dominate the cottonwood riparian

Woodpecker on the National Elk Refuge.

habitat along Flat Creek. This is typical of highly fragmented cottonwood habitat and the species-poor avifauna it supports (Gutzwiller and Anderson 1987). Many native cavity nesters cannot successfully compete with the highly aggressive starling. Aspen stands on the refuge also have low abundances of key native species that are aspen obligates, such as red-naped sapsucker and MacGillivray's warbler (Anderson and Anderson 2001). Some widespread habitat specialists are completely absent, including the broad-tailed hummingbird, calliope hummingbird, rufous hummingbird, veery, Swainson's thrush, orange-crowned warbler, black-headed grosbeak, fox sparrow, and song sparrow (Dieni and Anderson 1997).

The decline of woody vegetation on the National Elk Refuge and the resultant decline in Neotropical migrants is attributed to 90 years of heavy browsing by elk and more recently by bison. Anderson (2002) conducted a study in and around Jackson Hole specifically to determine the effect, if any, that supplementally fed elk were having on landbird distribution in upland aspen and riparian habitats. His results can be summarized as follows:

Aspen woodland habitats that were browsed heavily by elk were characterized by (1) less understory volume of vegetation, (2) lower densities of non-sapling live and dead trees, (3) greater proportions of dead aspen trees (non-sapling), (4) more regeneration of suckers less than 0.5 meter, (5) less recruitment to overstory, (6) lower density of aspen saplings, (7) lower proportion of the stands contained saplings, (8) higher rates of sucker browsing, (9) lower proportion of suckers, (10) more damage to bark, (11) higher density of dead trees, and (12) higher proportion of the stands contained dead aspen trees. Aspen woodland habitats heavily browsed by elk were also characterized by (1) fewer species of birds that nest and feed in the understory, (2) fewer species of birds that nest and feed in forest canopies, (3) fewer ground-nesting species, and (4) a greater abundance of cavity-nesting birds, probably due to the higher rates of aspen decay and mortality. Aspen stands on the National Elk Refuge that received high elk use (i.e., stands with the longest duration of high elk densities) had a significantly lower diversity of birds, and birds were less abundant as compared to aspen stands with low elk use. When aspen stands are converted to sagebrush shrubland habitat by high elk use, there is an exchange of approximately 20–40 bird species for 3–5 bird species that are generally more common than those found in aspen stands.

Riparian woodland habitats that are heavily browsed by elk are characterized by (1) lower willow volume, (2) lower willow shrub diameter, (3) fewer willow habitat bird specialists, (4) fewer species that nest in willow, and (5) fewer aerially foraging species. Riparian areas closest to feedgrounds receive the heaviest elk use and experience the greatest loss in bird species that are riparian obligates, such as willow flycatchers, yellow warblers, MacGillivray's warblers, fox sparrows, and song sparrows. Species of birds that are abundant near feedgrounds include those that typically nest in sagebrush or grasslands, such as savannah sparrows, vesper sparrows, western meadowlarks, and Brewer's blackbirds. Nest predators, such as common ravens and black-billed magpies, were also more common near feedgrounds, possibly due to the greater availability of elk carcasses. These nest predators may accelerate the decline of Neotropical migrants. Anderson (2002) emphasized that recruitment of aspen and willow was extremely rare both on the National Elk Refuge and near WGFD Gros Ventre feedgrounds.

Cultivated Fields

Neotropical migrants that can be found in the cultivated fields on the National Elk Refuge and formerly agricultural lands in Grand Teton National Park include western meadowlarks, savannah sparrows, Brewer's sparrows, and vesper sparrows. These species also occur in native grasslands.

GALLINACEOUS BIRDS

Greater Sage Grouse

On the National Elk Refuge the sage grouse population has been sporadically monitored since 1977. Only one of two historical leks remain active on the refuge, and numbers of sage grouse counted in the leks have ranged from a high of 157 to a low of 2 (NER files). In spring 2005, 37 grouse were counted. Only one female has been known to nest on the refuge in recent years (Halloran, Anderson, and Holtby 2001).

In Grand Teton National Park the sage grouse population has been monitored annually since 1986, and earlier surveys date to the 1940s. The sage grouse decline in Grand Teton is at 79% (NPS 2002); only three of eight historical leks were active in 2005. In other areas changes in habitat are thought to be the primary cause of the observed declines, but the amount of sagebrush habitat within the park has changed little since surveys began in the 1940s. A survey was conducted in the park from 1999 to 2003 to determine the causes of this precipitous decline. During that time Halloran and Anderson (2004) found essentially stable sage grouse population growth in the park, and that a 6% increase in female annual survival combined with an 18% increase in productivity could result in a 10% annual population increase and viable population levels in approximately six years. Sagebrush habitat with increased residual grass cover, live and residual grass height, and forb cover and diversity was more likely to produce successful nests. Chick survival was positively correlated with increased forb cover and diversity, plus numbers of optimally sized insects (Halloran and Anderson 2004). They identified winter habitat, which consists of relatively flat south- to west-facing slopes with increased sagebrush canopy cover and height, as a potential limiting factor for sage grouse populations growth in Jackson Hole. In addition, the airport lek population has been affected by construction, sagebrush clearing, strikes by aircraft, and possibly fencing that provides predators with a convenient perch.

Greater sage grouse nest only in sagebrush habitat, using bunch grasses and sagebrush plants as cover (Kaufman 1996). Other important habitats include meadows and grasslands close to sagebrush habitat. In Jackson Hole the sage grouse population has decreased by 70% in recent years (Bohne, pers. comm. 2002). Factors that may be contributing to this local decline are loss of habitat to human development, prescribed burning of winter range, airstrikes at the airport, and browsing and grazing by livestock and large numbers of elk and bison.

Forest Grouse

Ruffed grouse are generally widespread and common, occurring in deciduous and mixed woodlands. Conifer forests may be used for shelter, while deciduous habitats are primarily used for food. Because elk browse on the woody vegetation that ruffed grouse rely on for their winter diet, changes in woody vegetation may affect ruffed grouse populations on the refuge.

Blue grouse are fairly common inhabitants of deciduous and mixed forests in the mountains during the summer. Blue grouse, elk, and bison share deciduous and mixed forest habitat in summer, but there is probably little competition between them since they feed on different plants.

WATERFOWL, SHOREBIRDS, RAILS, AND CRANES

Waterfowl, shorebird, rail, and crane species in the analysis area are diverse and, in most cases, have habitat linked to aquatic or wetland features. They are vulnerable to predators because of their location on the ground and they must rely on dense vegetation for camouflage or water levels high enough to impede nest raiders.

Several species of waterfowl — trumpeter swans, Canada geese, mallards, green-winged teal, gadwalls, American widgeons, common and Barrow's golden-eyes, and common mergansers — are year-round residents in National Elk Refuge wetlands, but most waterfowl and shorebird species in the Jackson Hole area are seasonal migrants. Rocky Mountain Canada geese nest on the wetlands throughout Jackson Hole, and fall populations on the refuge number 300–500, with 100 or so overwintering. Duck populations range from 200 to 500 annually, with gadwall, mallard, ring-necked duck, green-winged teal, cinnamon teal, and Barrow's golden-eye the largest contributors. Fall peak waterfowl populations number near 3,000 and about 200–300 birds overwinter on the refuge. The greater sandhill crane nests in small numbers in Jackson Hole, and fall concentrations of more than 150 birds have been observed on the refuge.

REPTILES AND AMPHIBIANS

Only 11 reptile and amphibian species are present in the Jackson Hole Valley, because of the high altitude and its associated cool climate. Most species are observed throughout the valley floor and foothill regions, especially along the Snake River, Buffalo Fork, and Gros Ventre River floodplains; some also inhabit the mountains up to 10,000 feet elevation. Several of the reptile species are rare, with apparently restricted distributions, including the northern sagebrush lizard, the valley garter snake, and the gopher snake. The nonnative bullfrog is known to exist only in the Kelly warm springs and nearby areas, where it was introduced decades ago (Koch and Peterson 1995).

Amphibian surveys conducted in 2000–2003 documented the occurrence of five species of amphibians — the blotched tiger salamander, the boreal toad, the boreal chorus frog, the Columbia spotted frog, and the nonnative bullfrog (Patla and Peterson 2004).

Recent surveys conducted in the Flat Creek and Gros Ventre drainages on the National Elk Refuge have documented breeding sites for four amphibians (the blotched tiger salamander, boreal toad, boreal chorus frog, and Columbia spotted frog) and the occurrence of the wandering garter snake (Patla 1998, 2000). Tiger salamanders are rare on the refuge, although they are quite common in Bridger-Teton National Forest. Boreal toads are widespread on the refuge, with breeding populations in the Flat Creek and Gros Ventre watersheds (Patla 1998, 2000, 2004). There are few Columbia spotted frogs on the Flat Creek drainage, but they are widespread in the Gros Ventre drainage. The most widespread amphibian on the refuge is the boreal chorus frog, which occurs in both drainages at multiple sites, but their breeding populations are unexpectedly small and scattered (Patla 2000).

The most significant and disturbing result of the amphibian surveys for the National Elk Refuge was the discovery in 2000 of amphibians killed by chytrid disease. This disease is caused by an aquatic fungus that has been associated with mass die-offs and population declines in many areas and may be contributing to the continuing and potentially escalating amphibian declines throughout the United State and the world (Patla 2000). This is the first time that this disease has been documented in northwestern Wyoming. Boreal toads are particularly susceptible to the disease. The boreal toad populations of southern Wyoming and Colorado are candidate species for the federal endangered species list and a state endangered species in Colorado (Patla 2000). A veterinarian with U.S. Geological Survey has stated, "The diagnosis of chytridiomycosis has potentially dire implications for all species of frogs and toads in the National Elk Refuge and, possibly, western Wyoming" (Green, pers. comm., as quoted in Patla 2000).

Since the discovery of chytrid disease on the National Elk Refuge in 2000, chytrid fungus has been found in several locations in Grand Teton and Yellowstone national parks and one location in Bridger-Teton National Forest. On the refuge live amphibians were tested for the presence of chytrid fungus on their skin; in 2003, 66% of the sampled amphibians tested positive for the fungus and in 2004, 71% (Patla 2004a; 2004b). Testing for chytrid also occurred in two park locations during the 2004 field season, with rates of 30%–85% among individuals tested (NPS 2004c). However skin tests on live animals may not accurately determine whether the amphibian is actually infected. As of the end of summer 2004, chytrid had not decimated the toad populations at the two main breeding sites on the refuge, and no indicators of a population decline on the refuge (such as mass mortality events or failed reproduction) have been observed (Patla 2004b).

Concentrated numbers of elk and bison may affect amphibians and their habitat by decreasing water quality, increasing streambank erosion, altering marsh and riparian vegetation, and possibly transporting chytrid fungus on their hoofs. Conversion from flood irrigation to sprinkler irrigation could reduce the amount of standing water available for amphibians. Human disturbance of ponds, wetlands, and the surrounding areas could result in adverse effects to amphibian habitat.

Amphibian species of special concern are the boreal toad *(Bufo boreas boreas)* and the northern leopard frog *(Rana pipiens)*. The boreal toad is thought to have declined in abundance in the greater Yellowstone ecosystem, and the northern leopard frog, documented to breed in Grand Teton National Park, is now extremely rare or absent (Koch and Peterson 1995). Both of these species inhabit a wide range of aquatic habitats, including ponds, wetlands, streamsides, riparian zones, forests, and meadows. They could be impacted by water pollution, chemical herbicides, or pesticides, wetland and streambank disturbances and diseases.

Two reptile species are of special concern in Jackson Hole. The northern sagebrush lizard *(Sceloporus graciosus graciosus)* is found at elevations up to 8,300 feet and is commonly associated with thermal areas in Yellowstone (NPS 1998a). The rubber boa *(Charina bottae)* often inhabits riparian zones and could be adversely affected by soil compaction or vegetation loss.

HUMAN HISTORY AND CULTURAL RESOURCES

INDIGENOUS PEOPLE OF WESTERN WYOMING

During prehistoric times, no one tribe claimed ownership of Jackson Hole. Native Americans living on surrounding lands used this neutral valley during the warm months. Severe winters prevented habitation. Traditional uses of the lands included hunting or fishing, collection of plants and minerals, and ceremonial activities.

The most prominent groups that occupied the eastern Idaho and western Wyoming area prior to settlement by Euro-Americans were the Bannock, Northern Shoshone, and Eastern Shoshone. Other American Indian tribal groups have some historic or continued association with lands now within the National Elk Refuge and Grand Teton National Park, including the Assiniboine, Athabascans, Comanche, Salish, Kiowa, Kootenai, Crow, Gros Ventre, Teton Sioux, Umatilla, and Nez Perce. In addition, the Arapaho, Blackfeet, Cheyenne, and other Siouan groups and people of the Plains made excursions into the region for hunting, warfare, and trade (Walker in prep.).

The Bannock are related to the Northern Paiute and are Uto Aztecan speakers who migrated from Oregon into the area of the Snake River plains. There they lived in peaceful cooperation among the Shoshone speakers who had arrived from the Plains. The merged Bannock and Northern Shoshone developed a single amalgamated culture that exhibited strong Plains Indian influences.

The Bannock and Shoshone occupied areas currently designated as eastern Idaho and western Wyoming. Eastern Idaho includes the upper Snake River plains, where higher rainfall produced grasses and forage that supported bison. Bison were by far the greatest food resource, providing an endless supply of food, clothing and shelter materials, and weapon and tool products.*

An early depiction of Native Americans hunting.

Emigration, continuing warfare among tribes, and gradual loss of forage after the 1840s limited the amount of bison taken for food supplies. The bison herds west of the Continental Divide were greatly diminished and decimated by 1850, primarily by Euro-American immigrants.

Another principal food was fish, which were taken in the spring, when other food supplies were low, and were either eaten fresh or preserved by sun-drying or smoking.

Next in importance to buffalo and fish were elk. As the tribes began to compete for resources when emigrations diminished the major game on the plains, they turned to the mountains. The mountains still provided game for subsistence, whether it was elk, bighorn sheep, moose, or deer. In addition, berries were still found along the river banks, and roots could still be dug in the surrounding hills. Native plants were also important to the prehistoric inhabitants of the Greater Yellowstone Area. Today, modern tribes still collect and use these plants for ceremonial and traditional purposes.

The Shoshone entered into a treaty with the United States July 2, 1863, that set apart for the

* Bison were also viewed as an earthly link to the spiritual world. For many tribes, even today bison represent power and strength. For example, the Shoshone believe that spiritual power is concentrated in the physical form of the bison. Many contemporary tribes maintain a spiritual connection with bison.

Shoshone Tribe a reservation of 44,672,000 acres located in Colorado, Utah, Idaho, and Wyoming. However, the Treaty of Fort Bridger of 1868 pared this down to less than 2.8 million acres, and it established both the Fort Hall Reservation in Idaho and the Wind River Reservation in Wyoming.

The Treaty of Fort Bridger also designated reservations for the Bannock, a suitable one to be selected for them in their present country.

The Bannock and Shoshone experienced extreme hardship subsequent to the treaties and later agreements that separated them from their aboriginal territories. Prohibitions of off-reservation hunting and meager rationing and diseases adversely affected the tribal populations and social health.

> The Indians herein named . . . will make said reservations their permanent home, and they will make no permanent settlement elsewhere; but they shall have the right to hunt on the unoccupied lands of the United States so long as game may be found there on, and so long as peace subsists among the whites and Indians, on the borders of the hunting districts.
>
> — Article 4. *Treaty between the United States of America and the eastern band of Shoshonees and the Bannack tribe of Indians.*

In 1874 a government agent persuaded the Shoshone to sell another half-million acres so that the area could be opened up to gold mining.

By the end of the 1800s tribal land bases were greatly diminished, and tribal rights to hunt were curtailed. In *Ward v. Race Horse* (1896), tribal hunting beyond the exterior boundaries of the reservations was curtailed because the Supreme Court reasoned that this provision was temporary, and when Wyoming was admitted into the Union, it did so on an equal footing as all other states without lands within the state being encumbered. Tribal hunting for the Bannock and Shoshone, beyond the boundaries of their reservations, was at an end.

After additional treaties, congressional acts, executive orders, and agreements, the Bannock and Shoshone now occupy the Fort Hall Reservation in eastern Idaho and the Duck Valley Reservation in southwestern Idaho. The Eastern Shoshone are on the Wind River Reservation in west-central Wyoming.

Other American Indian tribal groups (at least 15) have some historic or continued association with lands now within the National Elk Refuge and Grand Teton National Park (Walker in prep.). Traditional uses of the lands include hunting or fishing, collection of plants and/or minerals, and ceremonial activities.

EURO-AMERICAN HISTORY

John Colter, a member of the Lewis and Clark expedition and later an explorer and trader for the Manuel Fur Company, may have visited Jackson Hole in 1807. Other trappers and traders from the Missouri Fur Company trapped the rivers and streams of Jackson Hole in 1810–11 (Daugherty 1999). During the 1820s and 1830s Jackson Hole served as a crossroads of the fur trade in the northern Rocky Mountains.

Except for a few prospectors searching for gold, Jackson Hole was virtually deserted by Euro-Americans from the 1840s to the 1880s. However, three military surveys passed through the valley in the 1860s and early 1870s. These military surveys were followed by the Hayden surveys (1872, 1877, and 1878), which were sponsored by the U.S. Geological Survey and that explored the Jackson Hole and Yellowstone country. It was during the first Hayden survey in 1872 that the first photographs of the Tetons were taken by William H. Jackson.

In 1884 the first permanent settlers arrived and built cabins along Flat Creek inside the boundaries of the present-day National Elk Refuge. By 1900, 638 people resided in Jackson Hole (Daugherty 1999). The first homesteaders planted crops and raised cattle on small family ranches throughout the valley. Long cold winters with deep snows, poor soils, and dry conditions that required digging irrigation ditches to water crops made homesteading in Jackson Hole a very difficult endeavor. By 1900 many of the original settlers had already left the valley (Daugherty 1999). In 1912, when the U.S. government allocated money to buy up homesteads to set aside land for the National Elk Refuge, many homesteaders willingly sold their property and moved into town. In other parts of the valley cattle ranching continued and expanded through the 1930s (Daugherty 1999) and remained the mainstay of the economy into the 1960s (Charture Institute 2003).

In 1929, 96,000 acres were set aside to create a national park that included the Teton Range and the six glacial lakes at the base of the range. In 1943 Jackson Hole National Monument was created from a donation of 35,000 acres by John D. Rockefeller, Jr., through his Snake River Land Company, plus some national forest land. Grand Teton National Park and the Jackson Hole National Monument were merged in 1950, forming an enlarged 310,000-acre park.

Before Euro-American settlement, some researchers believe that most elk migrated out of Jackson Hole in the winter, but homesteaders gradually forced elk off traditional winter ranges both inside and outside the valley (Craighead 1952; Anderson 1958; Cromley 2000) and cut and stacked elk winter forage in Jackson Hole to feed domestic livestock. Even before the Jackson Hole environment was changed by the arrival of homesteaders, early hunters and settlers noted that winters of unusually heavy snow caused thousands of elk to starve to death. This situation ultimately led to the establishment of the National Elk Refuge in 1912.

Bison played no role in early settlers' lives due to the fact that bison had been extirpated from the valley by the 1840s. By 1900 less than 1,000 bison existed in the entire United States. Bison were reintroduced into Jackson Hole in 1948.

CULTURAL RESOURCES

ARCHEOLOGICAL RESOURCES

Archeologists have discovered evidence indicating that Native Americans have used the Jackson Hole Valley for at least 11,000 years. Shifting climate patterns and the resulting change in plant and animal communities, along with drought and fire, determined how and when the valley was utilized. From 11,000 B.P. to around 5,800 B.P. American Indians occupied the valley sporadically to hunt and to obtain obsidian and other lithic material for tools. Numerous tools, fire hearths, and roasting pits have been found, particularly around


Historic photo of Jackson, ca. late 1800s.

Jackson Lake, dating after 5,800 B.P. These people lived a hunter-gatherer lifestyle and traveled in small groups. Tipi rings begin to appear in the archeological record after 5,000 B.P., and a few can be found on the National Elk Refuge and in Grand Teton National Park, but there is no evidence that Native Americans ever permanently resided in Jackson Hole.

In the northern part of Jackson Hole most evidence indicates that large base camps were established along the shores of Jackson Lake, where a band of individuals lived during the spring and early summer (Wright 1984). As the weather improved, the band would disperse into family groups and move into the canyons and higher alpine meadows, following the emergence of edible plant species. After using the resources of the higher mountains, the entire band would move into areas such as Idaho to spend the winter. The peoples of southern Jackson Hole entered the valley from the Gros Ventre drainage after wintering in the Green River, Wind River, or Big Horn basins of northwestern Wyoming. They followed the ripening plants south into the Gros Ventre Range and by the following winter had moved into the more mild inter-montane basins east of Jackson Hole (Daugherty 1999).

These prehistoric peoples primarily gathered plants for food, medicine, and manufacturing materials, but they also hunted mule deer, elk, bighorn sheep, and bison. Although bone does not preserve well, particularly in shallow soils, bison remains are present in 13 archeological sites in Jackson Hole and elk remains in 8 locations. Although archeological remains of bighorn sheep and mule deer are regionally numerous, no remains have been discovered in Jackson Hole (Cannon et al. 2001).

Archeological Sites on the National Elk Refuge

The majority of the land within the National Elk Refuge has not been inventoried for cultural resources; to date 10 sites have been identified and surveyed. Several features occurring on the refuge fall under the jurisdiction of the National Historic Preservation Act. Four prehistoric archeological sites have been recorded, which include roasting pits, stone circles, and a bison kill site. Among the artifacts that have been discovered are bones from bison and elk, numerous flakes, choppers, scrappers, and projectile point pieces.

Archeological Sites in Grand Teton National Park

Grand Teton National Park has an estimated 400 prehistoric sites, including hearths, roasting pits, tipi rings, lithic scatters, and sacred sites. A variety of projectile points, tools, cooking/storage vessels, and bison and elk bones have been uncovered at these sites.

ETHNOGRAPHIC RESOURCES

The alternatives could impact the tribes in how they view bison and elk in the context of their culture and traditions. Currently, an ethnographic resource study is being conducted that pertains to past treaties and traditional cultural activities that occurred within Grand Teton National Park, Yellowstone National Park, and the National Elk Refuge (Walker in prep.). The final report could influence future cultural resource surveys and management on the National Elk Refuge and in Grand Teton National Park, and it could yield additional information on how tribes used these areas.

HUMAN HEALTH AND SAFETY

TRAFFIC ACCIDENTS CAUSED BY BISON AND ELK

Visitors in the Jackson Hole area may be injured in vehicle collisions with elk or bison, either from animals crossing roads or with cars whose passengers are stopping to view these species. In Grand Teton National Park there were 97 collisions with elk from 1997 through 2001 (with a maximum of 24 in a year), compared to 14 with bison (a maximum of 6 in a year). From the north end of the town of Jackson, to the south entrance of the park, 10 vehicles hit elk; no collisions with bison happened from 1997 through 2001 on this section of U.S. 26/89 (Riegel, pers. comm. 2003).

ELK AND BISON ENCOUNTERS WITH PEOPLE

Although elk have not been aggressive to humans in Grand Teton National Park or the National Elk Refuge, incidents have occurred elsewhere. Although generally tolerant of humans, elk may assume a dominant head-high body posture when passing humans closely, display threat postures, and when harassed or startled, may aggressively attack. Bulls in rut are especially inclined to respond aggressively (Geist 2002).

Bison may be dangerous to humans and can charge and gore people if approached too closely. To date, Grand Teton Nation Park has not had the problems that Yellowstone National Park has had with bison gorings and aggressive encounters with people (Campbell, pers. comm. 2003). In 1993 the resident of a cabin on an inholding in Grand Teton National Park was gored; another resident was cited for feeding bison.

Bison crossing U.S. 191 near Elk Ranch Flats.

Conflicts between bison and residents of Kelly have occurred, particularly during spring when bison move north into the park from the refuge. Concerned citizens have reported bison in their yards, and occasionally animals have been hazed out of town and into the park. There have been no human injuries. Reports of conflicts between bison and people in Kelly decreased in early 2003, possibly because of the prescribed burn area near the town. Bison may have been spending more time in a burned area and less in Kelly compared to previous years (Campbell, pers. comm. 2003).

HUNTING ACCIDENTS

Hunting accidents have caused very few human injuries in the park or the refuge (Campbell, pers. comm. 2003; Griffin, pers. comm. 2003). To hunt in either area, elk hunters must successfully complete a hunter safety course and possess a hunter safety certificate. Firearms must be carried unloaded, and they must be dismantled or cased while in transit. Fluorescent orange exterior garments, as prescribed by state regulations, must be worn while hunting on the refuge (USFWS 2002b). Hunters are strongly encouraged to wear these garments in Grand Teton National Park. Also, a 0.25-mile-wide area along U.S. 26, 89, 191, 287 is closed to all hunting. No firearms may be discharged within 0.5 mile of any building within Grand Teton National Park (NPS and Wyoming Game and Fish Commission [WGFC] 2002; WGFC 2003). Clearly defined hunting areas and shooting hours also help prevent accidental injuries to people.

POTENTIAL FOR DISEASE TRANSMISSION TO HUMANS

Bovine Brucellosis — Humans are susceptible to brucellosis, however, only two cases of brucellosis have been reported where hunters contracted the disease from elk (Thorne 2001). The primary risk of transmission from elk or bison to humans is from hunter contact with organs of an infected animal. During the fall the disease is localized in tissues that are removed during field dressing (Thorne et al. 1982). Therefore, under normal circumstances, the risk to humans would be low (Thorne et al. 1982). The risk would be highest if hunters field dressed a pregnant elk or bison. Preventive measures, such as wearing rubber gloves when field-dressing the animal and avoiding direct contact and handling of reproductive organs and lymph tissues, should minimize risk.

Septicemic Pasteurellosis — Most *Pasteurella* infections in humans occur as wound infections following dog and cat bites (Thorne et al. 1982). Infections in the upper respiratory tract are possible, but uncommon (Thorne et al. 1982); with proper medical care these infections are readily treatable. Wearing rubber gloves when handling elk or bison that appear to be sick would help reduce risk of exposure.

Bovine Tuberculosis and Paratuberculosis — Both bovine tuberculosis and paratuberculosis are slow developing, chronic diseases, and infected animals may not show clinical signs. Humans could contract these diseases during the hunting season through direct contact with the animals and internal organs. The probability of disease transmission to hunters, managers, or researchers who handle infected animals is likely low (Demarais et al. 2002). Wearing rubber/latex gloves when field dressing game animals would reduce risk of exposure.

Humans are susceptible to bovine tuberculosis, but this infection is fairly rare (Thorne et al. 2002). Bovine tuberculosis poses a greater risk to human health than does brucellosis because aerosol transmission is the primary route for transmission from animals to humans. Direct handling of elk or bison by people would pose the greatest risk. Humans have contracted bovine tuberculosis after handling infected elk (Clifton-Hadley et al. 2001; Fanning 1992; Stumpff 1982).

Bovine paratuberculosis is found in feces and is not transmitted via aerosols, although there may still be a risk that humans could contract this disease during the hunting season because of direct contact with the animal and its internal tissues. There has been speculation in recent years that bovine paratuberculosis may play a role in development of Crohn's disease in humans, however, the data are inconclusive (Van Kruiningen 1999). The importance of this disease to human health is currently unknown, and it is unlikely that humans would contract paratuberculosis from wild ungulates (Demarais et al. 2002).

Anthrax— Anthrax does not sustain itself in the Jackson Hole area. While humans can contract anthrax, hunting of elk or bison would likely not pose a risk. The course of the disease is so rapid that sick animals would probably die before hunters encountered them. Direct animal to animal transmission of the organism does not occur; hence, interspecies transmission is not a concern.

Chronic Wasting Disease — Currently there is no evidence that humans can contract chronic wasting disease, but it has not been shown that humans cannot contract the disease. If it is determined that humans may contract the disease from wild ungulates, extreme precautions would have to be taken to avoid infection.

Currently, people hunting in herds infected with chronic wasting disease are encouraged to use common sense measures to reduce risk. These measures include: (1) not harvesting an animal that appears to be sick, (2) using rubber gloves when field dressing an animal, (3) avoiding contact with the brain and spinal cord tissue, (4) thoroughly washing hands and knives, and (5) deboning meat from the carcass (Williams, Yuill, et al. 2002). If these precautions are taken, the risk to hunters is minimized.

Other Diseases — Diseases that would not affect humans are vesicular stomatitis, malignant catarrhal fever, necrotic stomatitis, bovine viral diarrhea, parainfluenza virus-3, bovine respiratory syncytial virus, helminths, and lungworms.

SOCIAL AND ECONOMIC CONDITIONS

RECREATIONAL OPPORTUNITIES

Biannual visitor surveys conducted by the Jackson Hole Chamber of Commerce consistently document that 80%–90% of valley tourists identify natural resource based activities (principally sightseeing and summer and winter outdoor sports and recreation) as their primary reasons for visiting Jackson Hole.

WILDLIFE VIEWING

National Elk Refuge

The National Elk Refuge had an average of 851,220 visitors per year from 1992 to 2001. In 2001 there were 881,361 visitors, of whom 780,299 participated in on-site interpretation and nature observation, including 24,664 sleigh riders, 304,987 stops at the visitor center, and 439,148 visitors using observational facilities such as auto turnouts. An additional 2,000 people participated in environmental education activities, and 99,062 people enjoyed recreational opportunities on refuge lands. Recreationists included 2,193 big game hunters, 3,600 anglers, and 93,394 people engaged in miscellaneous activities (including approximately 30,000 people walking, hiking, jogging, and biking on refuge roads). Except for certain main roads where most vehicular traffic and all foot traffic is confined, a large portion of the refuge is closed year-round to public use. Fishing is allowed on lower Flat Creek from August 1 to October 31 and throughout the regular fishing season on upper Flat Creek.

A 2002 survey of refuge sleigh ride visitors found that elk viewing was the most frequent local and nonlocal visitor activity, followed by sightseeing, snow skiing, and pleasure driving (Loomis and Caughlan 2004). The survey also asked about the overall importance of activities in terms of deciding to take recreation trips to the Jackson Hole area. The numbers in Table 3-11 reflect the average importance of an activity and its relative importance in terms of attracting people to the Jackson Hole area. As shown in the table, viewing the mountains was rated as the most important activity by local and nonlocal refuge visitors, followed by viewing elk, other wildlife, and bison (Loomis and Caughlan 2004).

Grand Teton National Park

Grand Teton National Park had an average of 2,458,886 recreational visits from 1991 to 2001. In

TABLE 3-11: RELATIVE IMPORTANCE OF DIFFERENT RECREATIONAL ACTIVITIES IN VISITORS DECIDING TO COME TO JACKSON HOLE

	National Elk Refuge Sleigh Ride Visitors		Grand Teton Summer Visitors	
	Nonlocal Visitors	Local Visitors	Nonlocal Visitors	Local Visitors
Sample Size	457	43	765	57
Viewing elk	3.11	3.40	3.06	3.08
Viewing bison	2.80	3.18	3.07	3.07
Viewing birds and other wildlife	3.01	3.38	3.26	3.15
View mountains	3.41	3.65	3.81	3.56
Hiking, mountain climbing	2.09	3.00	2.93	3.09
Hunting elk	1.49	1.64	1.15	1.62
Hunting bison	1.30	1.16	1.10	1.34
Other hunting	1.43	1.53	1.12	1.54
Rafting/canoeing	2.02	2.51	2.40	3.22
Fishing	1.99	2.61	1.81	2.67
Snow skiing	2.78	2.79	1.51	2.83
Snowmobiling	2.17	1.36	1.24	1.79
Sleigh ride	2.98	2.64	1.55	2.12
Festivals	2.11	2.16	1.87	1.80
Horseback riding	1.66	1.82	1.75	1.69
Biking / mountain biking	1.54	2.50	1.54	2.31

SOURCE: Loomis and Caughlan 2004.
NOTE: Visitors sampled in 2002. The numbers reflect a four-point scale, where one is not important and four is very important.

2001 there were 2,535,108 recreational visits. Approximately 1,107,672 people visited the visitor centers at Moose, Jenny Lake, and Colter Bay. Interpretive rangers informally contacted 29,767 visitors while roving the park (Fedorchak, pers. comm. 2003). In 2001, 69,386 visitors attended formal interpretive talks, and another 12,056 visitors watched demonstrations of pioneer skills and history. A total of 2,099 hunting permits were issued in 2001 for the elk reduction program.

A 2002 survey of summer visitors found that sightseeing was the most frequent non-local visitor activity, followed by bison viewing, hiking, and pleasure driving, then by elk viewing (Loomis and Caughlan 2004). For local visitors, sightseeing and hiking were the most frequent activities, while viewing bison ranked fifth and viewing elk sixth (Loomis and Caughlan 2004). As a reason for visitors taking recreation trips to the Jackson Hole area, viewing the mountains was rated as the most important for local and nonlocal visitors (see Table 3-11), viewing bison ranked third for nonlocal visitors and fifth for local visitors, and viewing elk ranked fourth for both local and nonlocal visitors (Loomis and Caughlan 2004).

Bridger-Teton National Forest

Bridger-Teton National Forest had an average of 2,738,100 visitors per year from 1985 to 1996, the last year that data are available (USFS 2001). These visitation statistics include areas outside the home range of the Jackson elk and bison herds. Of the 3,617,800 visitors in 1996, about 22% engaged in camping, picnicking, and swimming; 25% enjoyed mechanized travel and viewing scenery; about 25% participated in hiking, horseback riding, and water travel; 6% took part in winter sports; 7% stayed at resorts, cabins, and organization camps; 7% hunted; 3% fished; 1% were involved in nonconsumptive fish and wildlife use; and 3% took part in other recreational activities.

In 2002 Bridger-Teton National Forest participated in a national survey in which visitor use was measured and visitors were interviewed about their preference and satisfaction with their visit. Less than half of the survey respondents (46.5%) said that they viewed wildlife, and this was the primary activity for only 2% of the visitors. Viewing natural features (scenery, flowers, etc.) was participated in by 50.7% of the visitors, and this was the primary activity for 10% of the visitors.

HUNTING / PARK REDUCTION PROGRAM

Elk

National Elk Refuge

Elk hunting is allowed on the National Elk Refuge both to provide recreational opportunities to hunters and to help control the numbers of elk in the Jackson herd. Special permit are required, and hunting is confined to the northern portions of the refuge. Hunts are managed in cooperation with the Wyoming Game and Fish Department. Every Friday during hunting season hunters enter a lottery held at the Jackson Rodeo Grounds to acquire a permit to hunt for two or three days the following week. The first weekend of the season, usually in October, is a youth hunt (ages of 14 to 17). Bulls may be taken during the first week; the rest of the season is restricted to cow/calf hunting. From 1997 to 2001, an average of 2,116 permits to hunt were issued, with an average of 312 elk were killed each season. In 2004, 1,806 permits were issued and 179 elk were killed.

Grand Teton National Park / John D. Rockefeller, Jr., Memorial Parkway

Qualified and experienced hunters who are licensed by the state and deputized as rangers by the Secretary of the Interior, are allowed to participate in a legislatively authorized elk reduction in Grand Teton National Park when necessary for the proper management and protection of the herd. Only park lands east of the Snake River and those lands west of Jackson Lake and the Snake River that lie north of the 1929 northern park boundary of Grand Teton National Park are open to the elk herd reduction program . Each licensed deputized ranger is allowed to kill one elk. The average number of permits issued from 1997 to 2001 was 2,484; the average number of elk killed was 665. In 2001, 2,099 permits were issued, and 375 elk were killed.

Hunting for elk and other wildlife is legally authorized in John D. Rockefeller, Jr., Memorial Parkway and managed by the state of Wyoming.

Other Areas

The Jackson elk herd is also hunted on USFS lands in the Teton Wilderness and the Gros Ventre drainage. There is some concern that these herd segments experience disproportionate hunting pressure due to the fact that many elk from Grand Teton and southern Yellowstone avoid hunters by migrating on the west side of the Snake River and by crossing at night into the southern portion of the National Elk Refuge (where hunting is not allowed). As a result, Grand Teton National Park's segment of the herd grew while the Teton Wilderness, Gros Ventre, and Yellowstone National Park segments declined. The Wyoming Game and Fish Department sets the elk hunting season and determines the number of permits issued each season.

Bison

Bison hunting was allowed on the refuge during the 1989–90 season and for a short time in the fall of 1990. A total of 39 bison were taken during these two seasons. As previously explained, bison hunts were stopped as a result of lawsuits pending the completion of additional analysis of the impacts.

Bison hunting is not allowed in Grand Teton National Park.

ECONOMIC SETTING

LOCAL AND REGIONAL ECONOMY

Approximately 97% of Teton County's total land area is managed by the federal government, leaving only 3% of the county's land base in private ownership (see "Landownership in Western Wyoming" map). Of the total private lands, about 14,600 acres are under conservation easements and nearly 40,000 acres are in agricultural production, primarily to graze and raise hay for cattle. Conservation easements are held by the Jackson Hole Land Trust, Teton County Scenic Preserve Trust, and The Nature Conservancy. Approximately 26,000 acres of undeveloped private land in the Jackson Hole area are not protected from development through conservation easements, and an estimated 15,000 acres could be developed in the next few years (Jackson Hole Land Trust 2003).

The town of Jackson is the primary destination for visitor activities in the Jackson Hole area, and it serves as the gateway community to the National Elk Refuge, Grand Teton National Park, Bridger-Teton National Forest, and southern Yellowstone National Park. Mainly because of its scenic and recreational activities, Teton County's year-round population experienced more than a sixfold increase between 1960 and 2000 (Charture Institute 2003a).

The median cost of a house in Teton County nearly tripled between 1990 and 2000 (Charture Institute 2003a). Due to the high cost of living in Jackson, a large percentage of the town's tourist-based service and trade industry workforce lives in communities outside Teton County and commute to work in Jackson. The towns of Victor and Driggs in Teton County, Idaho, have been the most affected by this trend (Charture Institute 2003a). For the purposes of this economic analysis, the local economy includes both Teton County, Wyoming, and Teton County, Idaho.

The 2000 census estimated the total population for the two counties at 24,250 persons, of which 75% (18,251 persons) lived in Wyoming, and 25% (5,999 persons) in Idaho. Total full- and part-time employment in 2000 was estimated at 25,607 jobs, of which 89% (22,828 jobs) were in Wyoming and 11% (2,779 jobs) in Idaho (Bureau of Economic Analysis [BEA] 2002).

All of Wyoming was selected as the regional impact area to capture nonresident visitor spending for tourists en route to the Jackson area, as well as in Jackson. In order to only examine nonresident spending at the state level, Idaho was not included in the regional model. Included in this larger regional economy are Wyoming communities outside Teton County that could be impacted to a lesser extent by elk and bison management decisions, such as Dubois.

Local and regional employment for 2000 is shown in Table 3-12. Most jobs pertaining to the recreation and tourism industry are in the retail trade sector (spending on supplies, souvenirs, restaurants, and grocery stores) and the service sector (spending on hotels, gas stations, amusement, and recreational activities). Over 55% of the private sector jobs in the analysis area are retail trade or

TABLE 3-12: FULL- AND PART-TIME EMPLOYMENT BY INDUSTRY, TETON COUNTY, WY AND ID, AND WYOMING STATE — 2000

	Teton County, WY and ID		Wyoming	
Industry	No. of Jobs	Percentage of Analysis area Total	No. of Jobs	Percentage of State Total
Total farm	610	2.4%	12,624	3.8%
Total nonfarm	24,997	97.6%	315,982	96.2%
Private	22,486	87.8%	251,876	76.6%
Agricultural Services, forestry, fishing	580	2.3%	5,769	1.8%
Mining	[1]	---	19,385	5.9%
Construction	3,534	13.8%	24,878	7.6%
Manufacturing	639	2.5%	13,583	4.1%
Transportation / utilities	659	2.6%	17,158	5.2%
Wholesale trade	D[1]	---	8,812	2.7%
Retail trade	4,737	18.5%	57,825	17.6%
Insurance / real estate	2,566	10.0%	21,305	6.5%
Services	9,382	36.6%	83,161	25.3%
Government	2,511	9.8%	64,106	19.5%
Total Employment	**25,607**		**328,606**	

SOURCE: BEA 2002.
1. Not shown to avoid disclosure of confidential information, but the estimates for this are included in the totals.

service based, showing that the local economy is highly dependent on tourism for its job base.

Jackson's attractiveness as a place to live has become a bigger economic driver in terms of growth in population and personal income than the tourist industry (Charture Institute 2003a). As shown in Table 3-13 in 2000 average per capita personal income in Teton County, Wyoming, was well over $20,000 higher than the state or national averages (BEA 2002). According to IRS tax return data, Teton County, Wyoming, was ranked as the wealthiest county in the nation for 2002, and it has ranked either first or second in per return income since 1997 (*Jackson Hole News and Guide* 2004).

TABLE 3-13: LOCAL AND STATE PER CAPITA PERSONAL INCOME —2000

	Per Capita Income
Teton County Wyoming	$52,640
Teton County Idaho	$15,577
State of Wyoming	$27,941
United States	$29,760

ECONOMIC IMPACTS OF RECREATIONAL ACTIVITIES

Natural and scenic resource issues have a direct and profound effect on the economic well-being of the Jackson Hole area. Both employment and taxable sales receipts in the local economy are dominated by the retail and service sectors, fueled primarily by tourist activities (Jackson / Teton County, Wyoming 1994). Tourism is dominated by summer visitation followed by winter and the shoulder seasons. Since 1997 summer recreational visits to Grand Teton National Park have averaged about 2.6 million visitors, while those to Yellowstone surpass 3 million, and a large portion of these visitors travel through Jackson. Winter visitation is primarily linked to skiing, snowmobiling, and wildlife viewing.

Spending associated with recreational and tourist activities generates considerable economic benefits for the local and regional economies. Activities related to the management of the elk and bison can impact local and regional spending by winter and summer visitors, hunters, and outfitters. In 2002 visitor surveys were conducted with visitor groups who could be affected by the elk and bison management plan, specifically winter sleigh ride visitors on the National Elk Refuge and summer visitors to Grand Teton National Park (Loomis and Caughlan 2004). Researchers also worked with the Wyoming Game and Fish Department to survey elk hunters who hunted in a Jackson herd unit during the 2001 hunting season.

Major tourist expenditure categories include lodging, food, supplies, and recreational equipment rental. The income and employment resulting from visitor purchases from local businesses represent the direct effects of visitor spending within the economy. Secondary effects result from the purchases of supplies by local businesses from

Map

Landownership in Western Wyoming

input suppliers, and the related income and employment, as new employees of input supplier's use their incomes to purchase goods and services. These secondary effects are often referred to as the "multiplier effect." The sums of the direct and secondary effects describe the total economic impact of visitor spending in the local economy.

The visitor survey results were used to estimate daily visitor spending to determine the economic impacts associated with current visitation to the National Elk Refuge and Grand Teton National Park and impacts associated with wildlife viewing. Economic impacts are typically measured in terms of number of jobs lost or gained, and the associated result on employment income.

Wildlife Viewing

National Elk Refuge

The National Elk Refuge plays an active, albeit small, role in economic development in the local economy. The national prominence of the refuge and its proximity to Jackson ensures that many valley visitors either directly or indirectly use the refuge, but actual dollars generated from the refuge are minor. For example, its location along the most heavily traveled highway leading to and from Grand Teton and Yellowstone national parks and its vast expanses of scenic open space are integral to the visual experiences of visitors at no direct cost. In 1995 refuge visitor spending generated $1,557,900 in the local economy, representing about 2% of local economic activity (Laughland and Caudill 1997). Indirectly, total refuge-related economic activity generated 41 full- and part-time jobs, with a total employment income of $662,500. For each $1 of refuge budget expenditure, about $3.20 of total economic effects is generated (Laughland and Caudill 1997).

Winter educational sleigh rides operated on the refuge by a private commercial interest have generated annual income ranging between $110,805 and $233,638 over the past 10 years. Over the past 5 years, 24,367 visitors annually have taken sleigh rides. The U.S. Fish and Wildlife Service provides interpreters for the sleigh rides, and a portion of the proceeds go to the National Museum of Wildlife Art.

Spending by visitors who live outside the local area (Teton County, Wyoming and Idaho) generates economic benefits for the local community. Results from the 2002 sleigh ride survey indicate that 91.6% of the visitors were nonlocal (Loomis and Caughlan 2004). About 16% of the sleigh ride visitors indicated that visiting the National Elk Refuge was the primary purpose or sole destination of their trip, while 44% said it was one of many equally important reasons or destinations, and the remaining 40% said it was just an incidental or spur-of-the-moment stop on a trip taken for other purposes or to other destinations.

On average nonlocal sleigh ride visitors spent approximately $98 per person per day in the Jackson Hole area. At current visitation levels, this would total over $1,955,000 in the Jackson Hole area annually. The direct and secondary effects of this visitor spending would account for more than $1,006,000 annually in personal income and 49 jobs in Teton County (Wyoming and Idaho). This represents less than 1% of total local income and employment.

The visitor survey also showed that 80% of all sleigh ride visitors were nonresidents and that they spent approximately $108 per person per day in Wyoming, which includes expenditures in the Jackson Hole area plus the amount spent in the rest of Wyoming en route to Jackson Hole (Loomis and Caughlan 2004). At current visitation levels, nonresident sleigh ride visitors spend over $1,753,000 annually in Wyoming. Direct and secondary effects account for approximately $957,000 in personal income and 55 jobs in the state.

Grand Teton National Park

There were on average 2,644,316 annual recreational visitors to Grand Teton National Park between 1997 and 2001. However, since wildlife viewing in the park is primarily a summer activity, the visitor survey conducted for this planning process focused on summer and fall visits (Loomis and Caughlan 2004). The five-year average visitation of 2,349,069 from May through October was used as the baseline visitation for summer visitors.

Survey results indicate that 92.1% of the visitors (2,163,493) lived outside Teton County (in Wyoming or Idaho) (Loomis and Caughlan 2004). Of these visitors, 24% indicated that visiting Grand Teton was the primary purpose or sole destination of their trip, but 72% stated that it was one of many equally important reasons or destinations. Less than 5% of the visitors indicated that visiting the park was just an incidental or spur-of-the-moment stop on a trip taken for other purposes or to other destinations.

Survey results show that on average nonlocal park visitors spent approximately $83 per person per day locally in the Jackson Hole area. At current visitation levels, this visitor spending would total over $589,908,000 annually in the local area. This level of visitor spending directly accounts for $200,720,000 in personal income and 10,658 jobs in Teton County (in both Wyoming and Idaho), representing 19% of total local income and 42% of local employment. Including direct and secondary effects, visitor spending accounts for over $306,460,000 annually in personal income and 14,200 jobs in both counties. Current summer visitation to Grand Teton National Park accounts for almost 30% of total personal income and 56% of total employment in the Jackson Hole area (including direct and secondary effects), a substantial impact on the local economy.

The summer visitor survey shows that more than 90% of the total visitors were from out of state and that they spent approximately $110 per person per day in Wyoming, including expenditures in the Jackson Hole area and in the rest of Wyoming while en route to Jackson Hole. At current visitation levels, summer visitor spending totals over $729,820,000 annually in Wyoming. Including the direct and secondary effects, visitor spending accounts for about $391,767,000 in personal income and 21,588 jobs in Wyoming, or almost 3% of total personal income and 6.6% of total employment in the state.

Hunting and Outfitting

Elk Hunting

Elk hunters who hunted within the Jackson elk herd units during the 2001 hunting season were surveyed to quantify how much they spent in the local and regional economies and the associated economic impacts (Koontz and Loomis 2005). Major expenditure categories for elk hunters include outfitter/guide fees, hunting licenses and supplies, game processing, lodging, food, and gasoline.

The survey asked hunters to rank their most preferred federal land area for elk hunting in the Jackson area (Koontz and Loomis 2005). Over 75% of local hunters selected Bridger-Teton National Forest, and 28% selected Grand Teton National Park. (Percentages total more than 100% because several hunters selected two areas as their most preferred.) Almost 50% of local hunters chose Grand Teton as their second most preferred area. Approximately 56% of nonlocal hunters and out-of-state hunters stated that the park was their most preferred hunting area. Approximately 20% of out-of-state hunters, 11% of nonlocal hunters, and 10% of local hunters selected the National Elk Refuge as their most preferred hunting area.

According to the Wyoming Game and Fish Department, the economic return for each elk license sold in Wyoming is $482.50, and the economic return for each elk killed is $1,653. Therefore, the total economic value associated with elk hunting on the refuge in 1997 (2,241 permits issued) totaled about $1.08 million, up 39.4% from 1996. The 424 elk harvested on the refuge during the 1997 hunting season generated an additional $496,292.

Excluding license fees, nonlocal Wyoming hunters spent approximately $402 per trip and nonresident (or out-of-state) hunters spent approximately $1,383 per trip locally in the Jackson Hole area (Koontz and Loomis 2005). Table 3-14 shows the average amount spent per hunter per trip in Wyoming (excluding hunting license fees) for each federal land area.

Nonlocal Wyoming hunters who hunted on the refuge spent more on in-town services (restaurants, grocery stores, and hotels) than those who hunted in the park or the forest. The most noticeable difference in expenditures in Jackson Hole is that out-of-state hunters in the national forest spent on average $2,225 per trip, while out-of-state hunters in the park spent $937, and those on the refuge $1,107. Out-of-state hunters in Bridger-Teton spent an average of almost $1,500 per trip on outfitter / guide fees; a majority of the national forest hunt areas are designated wilderness, and Wyoming hunting regulations require nonresident hunters to be accompanied by a

TABLE 3-14: AVERAGE SPENDING PER TRIP IN WYOMING BY JACKSON ELK HERD HUNTERS DURING THE 2001 SEASON

Federal Land Area	Nonlocal Wyoming Residents	Hunters from Out-of-State
National Elk Refuge	$734	$1,305
Grand Teton National Park	$454	$1,201
Bridger-Teton National Forest	$301	$2,452

SOURCE: Koontz and Loomis 2005.
NOTE: Excludes license fees.

hunting/outfitting guide in national forest wilderness areas.

Fees for a 2001 WGFD hunting license were $38 for a resident bull elk tag, $33 for a resident cow/calf tag, $410 for a nonresident bull elk tag, and $160 for a nonresident cow/calf tag. Survey results show the average amount spent on a 2001 WGFD elk hunting license was $37 for local residents, $43 for nonlocal Wyoming residents, and $387 for nonresident hunters. (These fees are in addition to the spending reported in Table 3-14.)

For the five-year average (1997–2001) number of hunters, the direct and secondary effects of hunter spending accounted for over $4,926,300 in personal income and 270 jobs in Teton County (in both Wyoming and Idaho). About a third of the local jobs dependent on hunter spending are in the amusement and recreation services sector, primarily in outfitting and guide services.

Excluding license fees, nonresident hunters on the National Elk Refuge spent a total of approximately $1,305 per trip in Wyoming, in Grand Teton National Park $1,201, and in Bridger-Teton National Forest $2,452. This includes reported spending in the Jackson Hole area, as well as the amount spent in the rest of Wyoming on the way to Jackson Hole from 1997 to 2001 the direct and secondary effects of nonresident hunter expenditures accounted for over $4,096,100 in personal income and 259 jobs in Wyoming.

Bison Hunting

Bison are considered trophy animals for big-game hunters, and they are hunted on both public lands and private game ranches in North America.

Bison hunts on public lands are now allowed in Wyoming, Utah, South Dakota, and Alaska. Lotteries are held for the Wyoming, Utah, and Alaska hunts, with a percentage of the permits reserved for resident applicants. A nonrefundable application fee of $5 to $10 is required. Permits for nonresidents range from $1,008 to $2,605, and for residents from $0 (Alaska) to $1,105 (Utah). Hunters must have state big-game hunting licenses.

Bison hunting was allowed on the National Elk Refuge during the 1989–90 season and for a short time in the fall of 1990. A total of 39 bison were taken during these two seasons. This bison hunt generated considerable interest, with over 3,000 applications being received during the first drawing for 16 permits in 1990. Results from the 2001 Jackson elk hunter survey indicate that allowing bison hunting on the refuge is still very desirable, with 76% of local Wyoming residents, 80% of nonlocal Wyoming residents, and 61% of out-of-state hunters stating they would apply for a bison tag (Koontz and Loomis 2005).

OTHER ECONOMIC IMPACTS RELATED TO ELK AND BISON

ANTLER SALES

Since the late 1950s the Jackson District Boy Scouts have picked up elk antlers on the National Elk Refuge each spring under a special use permit. This program reduces damage to feeding equipment, prevents trespassing by antler thieves, and stops unnecessary disturbance to the elk herds. The antlers are sorted, bundled, weighed, tagged, and sold at a public auction in the Jackson town square each May. More than 150 bidders from 28 states, representing local buyers, Asian markets, western export houses, and regional crafts people, usually attend. Approximately 80% of the proceeds from the auction are donated by the scouts to the U.S. Fish and Wildlife Service toward elk management, including the farming and irrigation program and feeding equipment. The total amount received in 2003 was $58,263 for 7,870 pounds of antlers, compared to $80,656 for 9,755 pounds of antlers in 2002. Antler poundage was down in 2003 due to the early spring migration from the refuge. The 10-year average dollar amount received from the auction is over $89,800.

Boy Scout spring antler auction in Jackson.

Landscaping Impacts from Wildlife Browsing

Landscaping has become a thriving business in the Jackson Hole area, growing from fewer than five nursery/landscaping companies over 20 years ago to more than 35 now.

For a typical lot in town landscaped by homeowners, the cost of plant material (trees, shrubs, and flowers) ranges from $500 to $3,000. For many new homes, professional landscaping costs may range from $20,000 to $50,000 (Prevost, pers. comm. 2004). Plant materials for these projects typically cost $2,000–$3,000. It is not uncommon for homeowners in some subdivisions to pay $100,000 or more for a complete landscaping package, in which plant material could be $13,000 or more.

Residents in some subdivisions (e.g., the Solitude subdivision) currently have landscaping companies install temporary devices in the fall and dismantle them in the spring to protect plants from elk, moose, and other wildlife (Prevost, pers. comm. 2004). Average annual costs are $500–$1,000, but some costs run as high as $2,500 to $4,000 per year. In areas where elk and other wildlife cause damage, mortality of trees and shrubs typically does not exceed 10%–15% of the plants, but in some situations it can be as high as about 30% (Prevost, pers. comm. 2004).

LIVESTOCK OPERATIONS

Jackson Hole Area

The livestock industry in the Jackson Hole area and in the broader region is represented primarily by cow-calf operations. A portion of the cattle in the Jackson Hole area spend the summer in Bridger-Teton National Forest or Grand Teton National Park under grazing permits that authorize livestock grazing on federal lands. Cattle are returned to their home ranches at the end of the allotment period in the fall (or earlier due to snowfall or other reasons), where hay sources are more accessible.

Yearly phases of production include weaning calves, feeding or selling steers and surplus heifer calves, and culling old or unbred cows. Owners of cow-calf operations usually do not purchase cattle, with the exception of breeding bulls; rather they rely on replacement heifers from the same herd. Their incomes generally reflect the 10- to 12-year price cycle for beef. Income in some years may not cover expenses, but a positive cash flow is usually realized at the end of the cycle.

As of January 1, 2002, there were a total of 9,000 cattle on ranches and farms in Teton County, Wyoming, with a value of $7.2 million, which is less than 1% of the state total (the statewide average per head is $760, as of January 1, 2003; Wyoming Agricultural Statistics Service 2003). The most recent census data show that in 1997 there were 13,025 cattle on 41 ranches in Teton County, including 15 ranches with 200 or more cattle each. In 1997 the value of all cattle sold in Teton County was $2.9 million.

Table 3-15 shows the number of cattle (cow-calf pairs) permitted on federal grazing allotments in the park and national forest, as well as those allotments that were actually used in 2002. Permits typically specify the maximum number of cattle allowed to graze and the grazing dates. Permittees have the option of whether or not to use their allotments and to what degree.

TABLE 3-15: NUMBER OF CATTLE (COW-CALF PAIRS) PERMITTED ON PUBLIC LAND GRAZING ALLOTMENTS IN GRAND TETON NATIONAL PARK AND BRIDGER-TETON NATIONAL FOREST

Public Allotment Name	Acreage	Number of Cattle	On/Off Date
Grand Teton National Park[1]			
Gros Ventre (south)[2]	3,114	400	5/15–6/15
Gros Ventre (north)	872	[2]	6/16–6/25
Lower Cunningham	456	[2]	6/26
West Elk Ranch	2,339	[2]	6/27–10/20
East Elk Ranch (south)[3]	500	[2]	7/1–10/20
Elk Ranch East (north)[3]	647	[2]	7/1–10/20
Pacific Creek	9,729	160	6/1–9/25
Total	17,657		
Bridger-Teton National Forest[4]			
Bacon Creek	66,777	168 +650 yearlings	6/11–10/15
Big Cow Creek	4,382	15	6/19–9/15
Ditch Creek	*35,567*	*390*	*7/1–10/31*
Lava Creek (excl. Burro Hill)	*25,347*	*320*	*6/1–10/15*
Lava Creek (Burro Hill)	1,208	55	6/1–10/15
Fish Creek	113,871	573	6/11–10/15
Kinky Creek	*22,964*	*174*	*7/1–8/30*
Miner's Creek	11,843	92	6/21–10/15
Pacific Creek[5]	11,646	249	6/1–8/22
Redmond/Bierer	7,200	30	6/15–9/26
Upper Gros Ventre	*67,358*	*550*	*6/18–10/8*
Granite Creek	25,750	300	6/16–10/5
Munger Mountain	*38,848*	*379*	*6/11–10/18*
Willow Creek	*38,773*	*250*	*7/1–9/30*
Porcupine Squaw Creek	*3,384*	*34*	*6/1–10/15*
Mosquito Fall Creek	*21,840*	*933*	*7/1–10/15*
Total	496,758		

NOTE: Rows in italics indicate allotments not used in 2002.

1. Two ranchers hold the permits for all of the park allotments — one permittee with 160 pairs uses the Pacific Creek allotment and another permittee with 400 pairs uses the other allotments at varying times. The latter's status is currently unknown. The herd was infected with brucellosis and depopulated in 2004. The permittee took non-use status for 2005.
2. Only two of the three pastures that comprise Gros Ventre (south) were used in 2002. The 400 cattle listed for Gros Ventre (south) are moved among the Gros Ventre / Lower Cunningham / Elk Ranch allotments.
3. There is also a 113-acre sick cow pasture on Elk Ranch East that can accommodate up to 20 head at any given time, from July 1 to October 20.
4. Each allotment in the national forest essentially represents a different rancher.
5. Only 160 cattle are permitted to use the Pacific Creek allotment from June 11 to August 3.

As shown in Table 3-15, all of the allotments in the park that could have been used were, in fact, used by permittees in 2002. By contrast, only about two-thirds of the national forest allotments were actually used by permittees in 2002. Two ranchers hold the permits for all of the park allotments — one permittee with 160 pairs uses the Pacific Creek allotment and another permittee with 400 pairs uses the other allotments at varying times. Each allotment in the national forest essentially represents a different rancher.

The exact number of cattle currently being grazed on private lands in the Jackson Hole area is not available. However, the local agricultural extension office estimates that there are 10 to 15 ranchers in the Jackson Hole area that do not graze their cattle on public lands. These ranchers graze an estimated 1,500 to 2,500 cow-calf pairs total, starting from about May 15 to June 1.

Although hard data are not available, no swine producers are known in Teton County, and as of January 1, 2002, there were no breeding sheep on Teton County farms and ranches. This is consistent with the most recent census data, which shows that there was only one farm with swine inventory and three farms with sheep inventory in the county in 1997. There are no deer farms in Wyoming and only one elk farm that was grandfathered in when the statute forbidding elk and deer ranching was passed in 1975.

Green River Basin and Red Desert

Livestock grazing is currently authorized on six livestock grazing allotments on 169,000 acres in the Pinedale Ranger District of Bridger-Teton National Forest (USFS 2004b). Nearly all of the use (99%) is by cow-calf pairs; the remaining 1% is by yearlings. The season of use is generally mid-June through mid-October, but some cattle are grazed from early or mid-July through late September or mid-October.

On BLM lands livestock grazing is authorized on 206 allotments covering a little over 900,000 acres in the Pinedale Resource Management Area (BLM 1986) and on 79 allotments on approximately 3.5 million acres in the Green River Resource Management Area (BLM 1996b). Season of use throughout most of the two resource management areas is spring, summer, and fall, although some allotments include winter grazing.

Most of the livestock grazed on BLM, USFS, and other federal lands in the Green River basin and the Red Desert are grazed or fed on home ranches in Sublette and Sweetwater counties. As of January 1, 2003, there were a total of 45,000 cattle on ranches and farms in Sublette County, with a value of $34.2 million (Wyoming Agricultural Statistics Service 2003). In terms of number of cattle, Sublette County accounted for 3.5% of the state total on that date. The most recent census data show that in 1997 there were 72,279 cattle on 202 farms in Sublette County, including 97 farms with 200 or more cattle each. The value of all cattle sold in Sublette County in 1997 was $24.2 million.

As of January 1, 2003, there were a total of 16,000 cattle on ranches and farms in Sweetwater County, with a value of $12.2 million. (Only a portion of these ranches and farms are within the area that could potentially be occupied by elk from the Jackson elk herd unit.) In terms of the number of cattle, Sweetwater County accounted for 1.2% of the state total on that date. The most recent census data show that in 1997 there were 22,361 cattle on 104 farms in Sweetwater County, including 35 farms with 200 or more cattle each. The value of all cattle sold in Sweetwater County in 1997 totaled $5.0 million.

Brucellosis

Brucellosis is a key issue in this planning process because (1) the Jackson elk and bison herds and other elk herds in western Wyoming are chronically infected with the disease, (2) it is possible for the disease to be transmitted from elk and bison to cattle, and (3) brucellosis can adversely impact livestock production and affect human health. Brucellosis is a contagious disease whose main threat is to cattle and swine. The disease causes decreased milk production, weight loss, loss of young, infertility, and lameness. There is no cure for brucellosis in animals, nor is there a preventative vaccine that is 100% effective. (In humans the disease is known as undulant fever because of the severe intermittent fever and infection.)

In December 2003 brucellosis was confirmed in a herd near Boulder, Wyoming, about 100 miles southeast of Grand Teton National Park, and in January 2004, the disease was confirmed in a second herd near Worland, in north-central Wyoming. As a result, Wyoming lost its previous class-free brucellosis status and was downgraded to class A status under federal regulations. Class A status requires a negative brucellosis test no more than 30 days prior to interstate movement for test-eligible cattle and bison.* Class A status also requires a state to conduct adequate in-state surveillance to progress toward class-free status. To comply with this requirement, Wyoming law now requires that test-eligible cattle and bison test negative for brucellosis no more than 30 days prior to a change of ownership. Prior to the

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* "Test-eligible" cattle/bison include sexually intact vaccinated and non-vaccinated females and bulls 18 months of age and older, and all pregnant or post-parturient animals regardless of age.

A change from class-free to class A status has also resulted in increased testing requirements for Wyoming dairy herds. In a class A state, the brucellosis ring test (BRT) must be conducted at least four times per year at approximately 90-day intervals. In a class-free state, the level of BRT surveillance is two brucellosis ring tests per year at approximately 6-month intervals. A change from class-free to class A status has meant that Wyoming's dairy producers have faced added testing and handling costs. Because dairy cows comprise only about 1% of all cows in Wyoming, this plan focuses on the impacts for cattle that move out-of-state and change ownership.

Map

Bison Calving Area and Livestock Allotments

downgrade in status (effective February 13, 2004), cattle in Wyoming were not required to be tested for brucellosis.

Wyoming can apply to have its class-free status reinstated if it complies with the class A testing and surveillance requirements for a minimum of one year and no other brucellosis infection is found in the state during that time. However, even if Wyoming is able to re-attain class-free status, the state will still need to continue an acceptable level of surveillance testing in order to maintain that status and to satisfy its trading partners that a "clean" product is being provided. Because two more Wyoming cattle herds tested positive for brucellosis in 2004, the brucellosis-free timeline was restarted in December 2004.

Although difficult to assess, the brucellosis outbreaks do not appear to have had a major adverse impact on market prices for Wyoming cattle. Prices for Wyoming cattle fell sharply in January 2004, but that decline has been widely attributed to the December 2003 discovery of Bovine spongiform encephalopathy (BSE) in a dairy cow in Washington State. Since January 2004, Wyoming cattle prices have stabilized and even increased; March 2004 prices were up over February 2004 prices. In both February 2004 and March 2004, cattle prices were up over the levels for the respective months in 2003. Wyoming will likely continue to reflect the strong overall cattle market that has been at or near record levels for the last several years due to tight cattle supplies (Gustafson, pers. comm. 2005).

Cattle producers in Wyoming with infected herds, as well as producers with herds in contact with or adjacent to the infected herds, have also faced the income disrupting effects of quarantines and/or animal depopulations. The epidemiological investigations conducted following the outbreak in Wyoming have, to date, necessitated the quarantine of 11 contact and adjacent herds in that state. (As of May 2005 about 26 cattle in one herd were still under quarantine.) Furthermore, to date approximately 935 cattle in Wyoming (280 in the infected herd near Boulder, Wyoming, and 655 in the Teton County herds) have been depopulated. (Cattle in the other initially infected herd near Worland were in a terminal feedlot destined for slaughter.) Even though the herd owner received indemnity payments, those payments probably do not fully compensate for lost future income that may have been predicated on years of selective breeding and culling. Producers with infected animals cannot be required to depopulate their herds, but they would be restricted in terms of where the herd could be moved.

The recent brucellosis discoveries in Wyoming should not have a crippling effect on the cattle industry statewide, given that brucellosis testing and testing-related costs represent only a small portion of producer annual production costs. Based on a test cost of $8 and hidden costs of $6, total brucellosis testing and testing-related costs of $14 per animal represent less than 2% of annual per animal production costs.* This is not to suggest that all producers in Wyoming would experience the same relative impact, as the financial circumstances of individual producers could vary. In 2004 Wyoming began reimbursing cattle owners for testing costs at $3.50 per animal.

NONMARKET VALUES

The wildlife and the natural environment of the Jackson Hole Valley are of substantial value to winter and summer park visitors, hunters, and others who value the idea that these resources are maintained in a viable state. Part of this value is reflected in the expenditures that visitors make for lodging, food, and other travel services. However, the main reason that visitors make the often long and expensive trip to this area is not primarily to eat in Jackson restaurants or to spend a night in a motel in Jackson. Visitors make these trips because the benefits exceed the dollar cost.

Benefit studies are concerned with the demand side of the tourist industry. Visitors are charged only nominal or no fees for refuge and park visits or the use of surrounding public lands for hunting or snowmobiling, so trip values do not have market prices. The nonmarket value of trips for both visitors and hunters is measured by how much they would be willing to pay over and above the

* Data from the USDA Economic Research Service show that cow-calf production costs, per bred cow, for the Basin and Range Farm Resource Region of the U.S. (which includes western Wyoming) totaled $1,060.76 in 2001.

costs of the trip before they would decide to forego the trip (Ward and Duffield 1992).

The 2002 visitor survey for this planning process asked respondents about their willingness to pay for their most recent trip experience (Loomis and Caughlan 2004). For winter refuge sleigh ride visitors, the estimated mean nonmarket value per group per trip was $25.24 for local Teton County, Wyoming, resident visitors and $51.78 for nonlocal visitors. For Grand Teton National Park summer visitors, the estimated mean nonmarket value per group per trip was $97 for local Teton County, Wyoming, resident visitors and $718 for nonlocal visitors. Two 1999 studies of visitors to Yellowstone National Park estimated the median nonmarket value of a trip to that park. It was estimated that this nonmarket value was $56 for the three-state resident summer visitors and $349 for summer nonresident visitors (Duffield, Patterson, and Neher 2000). A parallel study of winter visitors to Yellowstone found a median nonmarket trip value of $30 for local residents, and a median value of $145 for nonresidents (Duffield and Neher 1999).

These median estimates indicate that visits to the Greater Yellowstone Area, as one would expect, are highly valued experiences. However, it may be noted that this range of values is not without precedent for recreational trips. For example, a 1988 report estimated the value of elk hunting trips in some Montana districts at around $400 per trip (Loomis, Cooper, and Allen 1988). These values would likely be considerably higher today. The Montana Department of Fish, Wildlife and Parks is currently using variable market prices to sell outfitter-sponsored nonresident combination licenses (which are mainly purchased for elk hunting). The market-clearing price has been $835 for several years. It was estimated that the value per day of elk hunting in districts around Gardiner, Montana, was $92.08 in 1991 dollars (Duffield and Holliman 1988).

Wildlife viewing is an important aspect of the visitor experience on the National Elk Refuge and in Grand Teton National Park. It is likely that the abundance and variety of wildlife that a visitor actually sees affects the satisfaction and value placed on the trip. Duffield (1991) examined how the value of trips to Yellowstone National Park taken in October 1989 and August-September 1990 varied by whether the survey respondent had seen elk. The median trip value for regional residents (Idaho, Montana, Wyoming) was $22 higher if elk had been seen and $145 higher for nonresidents (Duffield 1991). This study also estimated the impact of a 20% decline in elk populations on trip value. It was estimated that this would lead to only a small (3%) change in the probability that any given visitor would see an elk. The corresponding change in trip values was also small: $0.63 for residents and $4.61 for nonresidents.

The economic value of Grand Teton National Park and the National Elk Refuge resources is only partly measured by the demand for onsite use by visitors, hunters, and others. These areas are clearly a resource of national and even international significance. Many individuals value the idea that this resource and its wildlife are being maintained in a viable state independent of whether they will actually be able to visit the area (USFWS 1994). This type of nonmarket value is sometimes termed “intrinsic,” or “existence,” or “bequest” value (Krutilla 1967). The existence of the resource itself (separate from direct use) or the motivation to provide the resource for future generations are the bases of this economic value.