A DESCRIPTION OF THE NATIONAL ELK REFUGE AND GRAND TETON NATIONAL PARK

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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 north 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.

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.

CLIMATE

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.

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).

An analysis of precipitation records from 1921 to 2002 gathered by a National Oceanic and Atmospheric Administration weather station in Jackson, Wyoming, showed no significant trends, either increasing or decreasing (Smith, Cole, and Dobkin 2004). Although temperature readings from 1931 to 2002 increased, calculations using the 1949–2001 Keetch-Byram Drought Index (KBDI) values, which evaluate upper level soil moisture content, revealed a “minor decline in drought conditions” (Smith, Cole, and Dobkin 2004, p. 98).

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 by way of an underground diversion that 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 for influencing 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, WY 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 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.

In 2002 the Teton County Conservation District implemented some source tracking of fecal coliforms. Results from DNA analysis showed that 34% of the coliforms came 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,

TABLE 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).

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, WY 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, WY 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) flow 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

Map

Management Units and Surface Hydrology of the NER resources contribute to vegetative diversity (including aquatic, wetland, and riparian plant communities), irrigation and forage production, groundwater discharge, and the scenic viewshed. They also 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 1998).

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 Grand Teton National 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 bison 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 that runs for approximately 8 miles along the south and west boundaries of the refuge and that keeps 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 there 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 2).

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

Scientific Name	Common Name
Aster borealis	Rush aster
Astragalus terminalis	Railhead milkvetch
Carex buxbaumii	Buxbaum's sedge
C. parryana	Parry sedge
C. sartwellii	Sartwell's sedge
C. scirpoidea scripiformis	Canadian single-spike sedge
Eriophorum viridicarination	Green-keeled cotton-grass
Heterotheca depressa	Teton golden aster
Lesquerella carinata	Keeled bladderpod
Muhlenbergia glomerata	Marsh muhly
Salix candida	Hoary willow
Scirpus rollandii	Pygmy bulrush
Utricularia intermedia	Flat-leaf bladderwort

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, 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 B lists scientific names for plant species.

TABLE 3: PLANT COMMUNITY TYPES — NATIONAL ELK REFUGE

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 bulrush, cattail, and sedge species. These stands develop to full stature each year depending on water availability. In marshland habitats considerable residual material remains under the bases of growing plants from the previous years' herbaceous growth, except in areas that have been burned. There is very little nonnative plant species invasion 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 (Smith, Cole, and Dobkin 2004). 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 disturbances have prevented trees or shrubs from becoming established. Native grasslands are 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 tap-rooted 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 (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

Four habitat classes have been defined for willow, aspen, and cottonwood communities, as shown in Table 4. Class I indicates good habitat quality; Class II, fair habitat quality; and Classes III and IV, poor condition habitat. Generally, the classes describe the extent of browsing, the condition of the vegetation type, and the extent of bird life as an indicator of community health.

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

TABLE 4: HABITAT TYPES AND CLASSIFICATION OF WILLOW, ASPEN, AND COTTONWOOD COMMUNITIES

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

SOURCE: Willow class definitions from Singer and Zeigenfuss (2003). Aspen and cottonwood class definitions formulated from Dobkin 1994; Dobkin, Singer, and Platts 2002; and field observations by E. K. Cole, National Elk Refuge biologist.

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.

Poor condition willow habitat.

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.

Poor condition cottonwood habitat.

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.

Poor condition aspen stand.

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 (2004) 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 annual growth). The decline of willows along Flat Creek in the southern portion of the refuge has exceeded 95% (Smith, Cole, and Dobkin 2004). Shrubby cinquefoil, a less palatable woody species, is abundant in this prior range of willows and has probably increased as willows 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 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 (E. K. Cole 2002a, 2002b).

Many aspen stands are characterized by mature trees, with little if any aspen understory. Aspen recruitment is prevented by heavy elk browsing on aspen suckers that 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 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 2004).

Cottonwood and aspen saplings grow inside exclosures (fenced areas) on the upper section of Flat Creek, indicating that 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, sub-irrigated bluegrass, smooth brome, and alfalfa. Smooth brome, the most common, provides moderate-quality standing forage but is undesirable because of its inability to remain erect in heavy snow. It also requires irrigation in drought years and may spread to suitable sites in other cultivated fields and native grassland habitats. Cultivated grasslands, which are planted specifically to augment native forage that is available for elk in the winter, 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. Only a portion of the

TABLE 5: 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**

approximately 2,400 acres available for cultivation would likely be cultivated in any particular year.

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 5). 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 water 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 per 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 per 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 6. The refuge produces an estimated average of 22,195 tons of forage annually, about 18,049 tons

TABLE 6: 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.

(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 6). 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. Retrospective analysis of forage production data against several possible explanatory variables found that precipitation accounted for most of the annual variability. For example, record-breaking precipitation in 1993 resulted in increased forage production. Another variable is grasshopper populations, which are typically associated with drought; they play a lesser role in forage production, but their exact effect is more difficult to quantify.

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

TABLE 7: NONNATIVE INVASIVE WEED SPECIES ON THE NATIONAL ELK REFUGE

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

GRAND TETON NATIONAL PARK

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. There are 117 nonnative species 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 the 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 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 certain riparian corridors within that area. Although elk and bison use coniferous forests for cover, these 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 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**

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 of these nonnative invasive species to outcompete native grasses and to expand their range (Haynes, pers. comm. 2003).

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 the park (McCloskey and Sexton 2002).

Additional plant species commonly found in riparian and aspen woodlands include species of rushes, Muhly, horsetail, yellow salsify, wheatgrasses, 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, sub-alpine 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 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 in the 1890s and early 1900s to produce pasture and hay for cattle in the winter months. An estimated 1,100 acres 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.

PLANTS SPECIES OF SPECIAL CONCERN

There are 52 Wyoming plant species of special concern in Grand Teton National Park (see Table 9).

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.

TABLE 9: WYOMING PLANT SPECIES OF SPECIAL CONCERN — GRAND TETON NATIONAL PARK

Scientific Name	Common Name	Scientific Name	Common Name
Adiantum pedatum	Aleutian maidenhair fern	*J. tweedyi*	Tweedy's rush
Agoseris lackschewitzii	Pink Agoseris	*Kelloggia galioides*	Milk Kelloggia
Aspidotis densa	Pod-fern	*Lesquerella fremontii*	Keeled bladderpod,
Astragalus terminalis	Railhead milkvetch	*L. paysonii*	Payson's bladderpod
A. shultziorum	Shultz's milkvetch	*Lemna valdiviana*	Pale duckweed
Athyrium distentifolium americanum	American alpine lady fern	*Listera convallarioides*	Broad-leaved twayblade
Carex leptalea	Bristly-stalk sedge	*Luzula glabrata hitchcockii*	Smooth wood-rush
C. cusickii	Cusick sedge	*Marsilea vestita oligospora*	Pepperwort
C. diandra	Lesser panicled sedge	*Najas guadalupensis*	Southern naiad
C. echinata	Little prickly sedge	*Orobanche corymbosa corymbosa*	Flat-top broomrape
C. laeviculmis	Smooth-stemmed sedge	*O. ludoviciana arenosa*	Louisiana broomrape
C. sartwellii	Sartwell's sedge	*Paeonia brownii*	Brown's peony
Draba borealis	Boreal draba	*Porterella carnosula*	Western porterella
D. crassa	Thick-leaved Whitlow-grass	*Potamogeton obtusifolius*	Blunt-leaf pondweed
Drosera anglica	English sundew	*P. friesii*	Fries pondweed
Dryopteris expansa	Spreading woodfern	*P. zosteriformis*	Flatstem pondweed
Eleocharis bella	Delicate spikerush	*Salix eriocephala mackenzieana*	Mackenzie's willow
Epipactis gigantea	Giant helleborine	*Senecio hydrophiloides*	Sweet-marsh butterweed
Equisetum fluviatile	Water horsetail	*Sparganium minimum*	Small bur-reed
Eriophorum viridicarinatum	Green keeled cotton-grass	*Spirodela polyrhiza*	Common water-flaxseed
E. gracile	Slender cotton-grass	*Stellaria crispa*	Crimped stitchwort
Gymnocarpium dryopteris	Oak-fern	*Torreyochloa pallida fernaldii*	Fernald alkali-grass
Heterotheca depressa	Teton golden aster	*Triteleia grandiflora*	Large flower triteleia
Hieracium scouleri	Scouler hawkweed	*Utricularia minor*	Lesser bladderwort
Huperzia selago	Fir clubmoss	*Viola pedatifida*	Western rough-leaved violet
Juncus filiformis	Thread rush	*Xerophyllum tenax*	Western beargrass

SOURCE: Fertig and Beauvais 1999.

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 (Allred 1950; Murie 1951; 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 farther south to the Red Desert, as shown on the "Possible Historical Elk Migration" map (Cromley 2000; C. 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 elk 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 (G. F. 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; C. Anderson 1958; B. L. 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; F. K. 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

Map

Possible Historical Elk Migration

government for help, and the Wyoming legislature appropriated money for elk feed. Additional 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 herd.

From 1998 to 2002 about 2,300 to 3,300 elk were harvested annually, resulting in approximately 16% of the pre-hunt Jackson elk herd population being removed each year. The 2005 harvest of 1,776 elk removed about 14% of the estimated 13,000 elk in the herd. Hunting on the refuge and the elk reduction program in Grand Teton National Park, along with WGFD harvests in Bridger-Teton National Forest and on non-federal lands, take place from mid-October to mid-December. These methods are used to bring total elk numbers as close as possible to the WGFD herd objective of 11,000. 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 12,855 for 2005–6 (Brimeyer, pers. comm. 2005). The herd was estimated to be as high as 19,657 elk in the mid 1990s, but annual harvests have gradually reduced it to current levels, within 2,000 animals of the WGFD objective of 11,000.

In winter 2005–6 the portion of the herd that wintered on refuge lands numbered approximately 6,800. The number of elk on refuge feedgrounds from 1991–92 to 2005–6 has been about 7,100, although numbers have ranged from 3,300 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 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 does the refuge. An average of 536 elk (a range of 206 to 1,299 elk) have wintered in the park (WGFD post-hunt classification counts for 1989–2003). Herd objectives are for an average number of elk in the park of about 356, with numbers ranging 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. L. 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).

G. F. 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 (G. F. 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. G. F. 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 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 (B. L. Smith 2000).

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 between summer and winter ranges, probably farther than other elk herds in North America (Preble 1911; Murie 1951; Boyce 1989). 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 (G. F. 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). Idaho Fish and Game monitoring studies have also documented mule deer and elk movements (Huffaker, pers. comm. 2005 for mule deer; Brown 1985 for elk) between eastern Idaho and western Wyoming.

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).

Male and female elk 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,

Map

Jackson Elk Herd Unit and Fall Migration Routes 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 RATIOS

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. Ratios from 2001 to 2005 ranged from 18 to 25 bulls per 100 cows.

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; C. 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 15 years, calf-to-cow ratios on the refuge have averaged 20 calves per 100 cows. Calf-to-cow ratios in the Jackson elk herd have averaged 25 per 100 cows, ranging from 20 to 31 per 100 cows. Reasons for lower ratios in some years are unknown but may have included increased harvest of female elk, predation, and/or drought (WGFD “2002 Annual Big Game Herd Unit Report”).

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.

According to Halfpenny and Ozanne (1989), ungulates generally start migrating when snow

Map

Elk Calving Areas

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 (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 the United States, and if either became established in this country, 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.

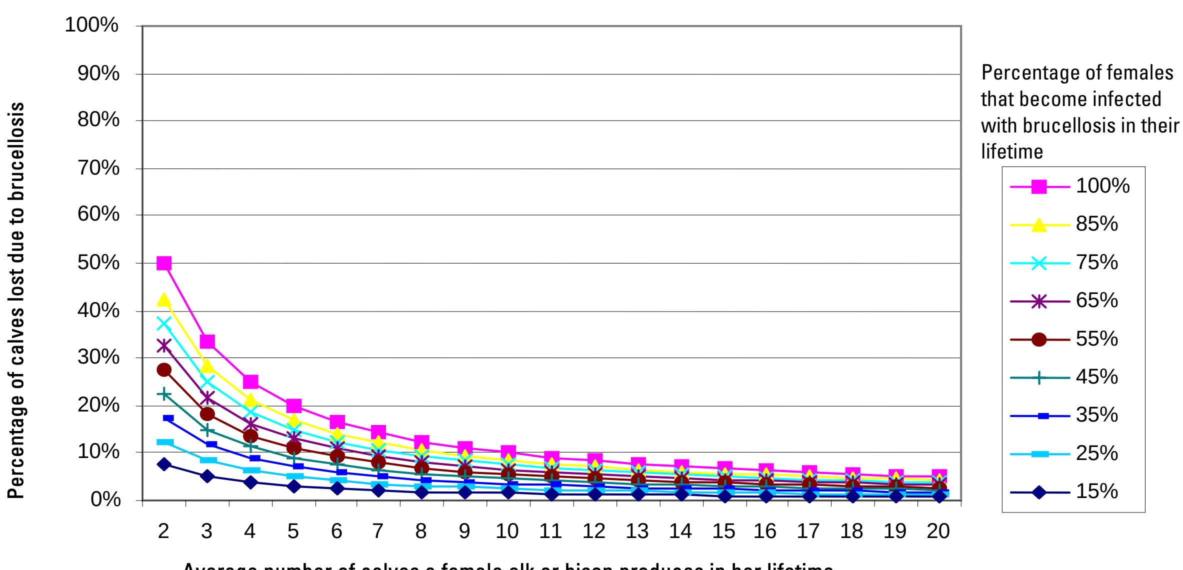
Although both sexes can contract the disease, transmission of brucellosis occurs by means of pregnant females when susceptible animals contact and ingest the bacterium *B. abortus* from infected aborted fetuses, fetal fluids, fetal membranes, or vaginal discharges (GYIBC 1997; Thorne 2001). Abortion 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% of female elk and 90% of female bison 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 among bison are high because animals tend to congregate. For example, the prevalence of brucellosis in infected free-ranging bison herds varies from 25% in Wood Buffalo National Park in

Canada (Tessaro, Forbes, and Turcotte 1990) to 70.3% in Yellowstone National Park ranges (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 (1995) contend that the primary route of transmission among bison is through the milk to calves, rather than from aborted fetuses. However, 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). The frequency of brucellosis-induced abortions in the Jackson herd is not known (GYIBC 1997), although there is no evidence that this is negatively affecting the growth rate of the bison herd.

Brucellosis transmission among elk is generally thought to be largely influenced by high concentrations of elk associated with winter feeding programs. Without winter feeding, Wyoming elk in areas adjacent to feedgrounds have an average prevalence of 2.3% (1990–2005) of the population, whereas refuge elk average 17% (1997–2005, excluding 1999; WGFD unpubl. data). 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. Transmission risk may also be increased if elk aborting during earlier stages of pregnancy behave differently from elk near the end of their pregnancy by not seeking seclusion. During a study of Strain 19 vaccine efficacy (Roffe et al. 2004), the researchers noted that infected elk aborting earlier in their term rarely segregated from other elk, whereas normally calving and stillbirthing elk did (Roffe, pers. comm. 2006). Brucellosis-induced abortions of elk calves in the

FIGURE 2: 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.

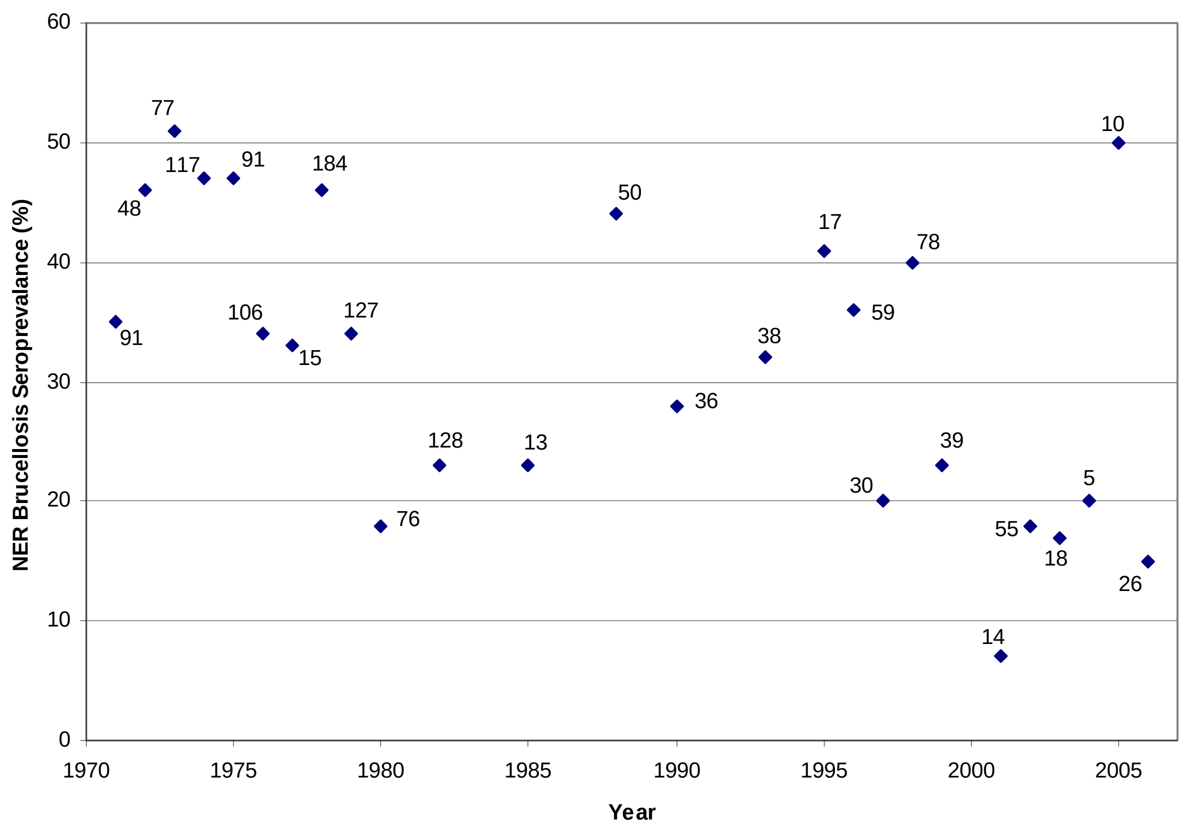
Jackson elk herd are estimated to account for 5%–7% calf loss (Oldemeyer, Robbins, and Smith 1993). A single brucellosis-induced abortion on a crowded elk feedground could expose many elk to brucellosis (Thorne 2001). Consequently, brucellosis in elk is primarily a problem among elk that utilize winter feedgrounds (B. L. 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 from infected elk (Hillman 2002). Elk in Wyoming 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 (GYIBC 1997):

1. Separation in space and time reduces the potential for transmission. In addition to management separation, separation may

FIGURE 3: PERCENTAGE OF BRUCELLOSIS-POSITIVE ELK TRAPPED ON THE NATIONAL ELK REFUGE, WINTERS 1970–71 THROUGH 2005–6



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, 2001, 2004, 2005, and 2006) to 184. Data from small samples should be interpreted with caution because the information is too limited to provide confidence that the information is accurate. These data do not represent prevalence in the Jackson elk herd as a whole.

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, although discharges will remain infectious for longer periods during cold weather. Direct sunlight quickly kills the organism. Scavenging by other wildlife reduces the occurrence of infectious 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.

Recent studies have added to information available on transmission potential related to the length of time the bacteria and/or aborted fetuses remain in the environment. Preliminary findings from 2001–3 studies in the Greater Yellowstone Area indicated that the bacteria persisted in the environment for varying periods depending on time of year and sun exposure (NPS et al. 2005). A study that simulated live bacteria with bison fetuses immersed in *B. abortus* strain RB51 vaccine and caged to protect them from scavengers found that the bacteria persisted longer in shady locations, on the bottom side of carcasses, and longer in February (from a few days to as long as 80–90 days) compared to mid-May (up to 20–30 days). UV-B radiation and temperature were environmental factors directly affecting bacterial survival.

Another study was done to determine how long it took for bison fetuses to be scavenged and disappear from the environment. Uninfected fetuses were placed both inside and outside Yellowstone National Park in 2001 and only in areas outside the park in 2002 and 2003. The flash from a motion-sensing camera that monitored half of the 2001 sites significantly deterred scavenging. On average, scavengers removed fetuses within 15 days but a few were not scavenged and remained until they decomposed 50 days later. In 2001 average disappearance rates were faster within the park than in adjacent areas, possibly due to human disturbance outside the park and differences in scavenger distribution and abundance (NPS et al. 2005).

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. Seroprevalence serves as a useful index to actual *B. abortus* prevalence in these populations.

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, bison, and cattle; 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 the 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 (B. L. Smith 2001; Disease Expert Meeting 2002). Outbreaks on the refuge have been related with extreme or harsh weather events (Franson and Smith 1988; B. L. 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. L. 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 and Footrot

Necrobacillosis refers to an array of diseases caused by the bacterium *Fusobacterium necrophorum*, of which necrotic stomatitis is one (Thorne et al. 2002). The bacterium inhabits the gastrointestinal tract and is excreted in feces. Disease occurs after a break in the skin or mucosa caused by abrasion or laceration allows the bacteria to invade. 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 document focuses on elk.

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

In winter 2005–6 an outbreak of footrot occurred among refuge elk during the feeding period. Compacted, icy snow conditions and feedgrounds, which are typically heavily contaminated with feces despite management attempts to feed in clean areas, likely contributed to elk susceptibility. Of total refuge mortalities from November 1, 2005, to April 18, 2006, 36% (48 of 220 elk) were associated with footrot.

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 (B. L. 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 believed that physiological stress and malnourishment during the rut, not summer or winter nutritional status, was the most important factor in scabies-related mortalities (B. L. Smith 1985).

During the winter of 2001–2, 61 mature bull elk on the refuge were classified as having scabies during a February survey; five bulls with clinical scabies had died earlier in the season. This amounted to 5.8% of mature bulls on the refuge. Nineteen (1.9% of branch-antlered bulls on the refuge) died during the winter 2005–6 (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.

Loads of lungworms in elk 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 the 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). The disease is primarily a disease of bison, with only rare, scattered instances of paratuberculosis-positive elk reported without documentation of mortality (Roffe, pers. comm. 2005).

Paratuberculosis has been reported sporadically in elk, both captive and free-ranging elk herds, and it is 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.

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 plan would do little to affect the prevalence of anthrax in Jackson elk and bison herds.

Undocumented Viral Microparasites — Malignant Catarrhal Fever

Domestic sheep are thought to be the source of the malignant catarrhal fever virus in bison and elk, and it is believed transmission may occur by means of 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 (TSE) like mad cow disease (bovine spongiform encephalopathy [BSE]) and scrapie, could infect the elk herd. Its origin is unknown, although it is more similar to sheep scrapie than to other transmissible spongiform encephalopathies. Eventually fatal and with no known treatment options, chronic wasting disease is especially concerning because it also contaminates the soil, where it is endemic. Current management options are limited; several states have quarantined and/or depopulated infected captive herds. Although originally limited to north-central Colorado and southeast Wyoming, recent outbreaks in other states and expansion in Wyoming have heightened concern about the disease's spread because it could be a significant mortality factor for elk. In addition, the TSE group of diseases has caused public concern for human health. A TSE in humans, variant Creutzfeldt-Jakob disease, has been linked to consumption of BSE-infected beef. Currently the World Health Organization and the U.S. Centers for Disease Control and Prevention have advised the public that "the risk to humans from CWD is extremely small, if it exists at all," but that people should avoid consuming meat from sick animals or those known to be infected with chronic wasting disease (Belay et al. 2004).

Chronic wasting disease is caused by a deleterious prion protein and is both infectious and contagious to mule deer, white-tailed deer, and elk (Williams, Miller, et al. 2002). A free-ranging moose was confirmed positive for chronic wasting disease in September 2005, but moose social habits make them a species that would likely have only rare occurrences of the disease (Colorado Division of Wildlife 2005). In instances when pronghorn, moose, bighorn sheep, mountain goats, cattle, sheep, and goats were in the same facilities as infected deer and elk or when they resided in facilities where chronic wasting disease had occurred, none developed the disease (Williams, Miller, et al. 2002).

The disease is transmitted by animal-to-animal contact or through contact with a contaminated environment, 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. Transmission may be influenced by animal numbers, the time infected animals occupy a given space, and the amount of space occupied by infected animals. It may also be related to the density of susceptible hosts. The density of animal populations would likely play a role through faster and greater seeding of the environment with the prion agent and more animal-to-animal contact.

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). Its spread in North America has been unpredictable (Williams, Miller, et al. 2002) and far reaching. As of June 2005, chronic wasting disease has been found in free-ranging elk, mule deer, and white-tailed deer in Colorado, Illinois, Nebraska, New Mexico, South Dakota, Utah, Wisconsin, West Virginia, Wyoming, and Alberta and Saskatchewan, Canada (see the "Chronic Wasting Disease in North America (2002–2005)" map). Kansas was added in early 2006. In Colorado and Wyoming chronic wasting disease has been moving westward for the past several years and is now found west of the Continental Divide (see the "Chronic Wasting Disease in Wyoming (2003–2005)" map).

In Wyoming new positive deer locations were found in 2003 near Worland and in 2005 in the Owl Creek drainage, both north and west of Thermopolis. The westernmost case was about 20 miles due west of Thermopolis on the Wind River Indian Reservation. These locations indicate that the disease is within approximately 90 miles of the Jackson elk herd unit boundary. Statewide surveillance was initiated in 2003, 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. In many cases infected captive deer and elk herds have been depopulated or quarantined, but some infected herds may remain. With increasing awareness of this disease, states are beginning to place moratoriums on the movement of captive cervids, and the U.S. Department of Agriculture is adopting a herd certification program (Williams, Miller, et al. 2002). With the increasing concern over the effect of chronic wasting disease on deer and elk populations, many states have instituted bans on translocations of cervids and have banned the import of cervid carcasses and high-risk carcass parts from CWD-affected states. Within affected states, the movement of animals and/or carcass parts from affected areas or zones is generally forbidden.

The prevalence of chronic wasting disease in free-ranging Wyoming elk ranged from 2.3% to 9.6% among elk hunt areas where the disease was sampled from 1997 to 2005, with an overall prevalence in these areas of about 4% (WGFD, unpubl. data 2005). Wyoming mule deer and white-tailed deer prevalence, combined, ranged from 2.9% to 7.6%; overall prevalence in deer was 6.5% (6.1% in mule deer and 10.6% in white-tailed deer). Examined separately, yearly total prevalence ranged from 4% to 7% in mule deer and from 6.0% to 18.1% in white-tailed deer (WGFD, unpubl. data 2005). None of the 55 Wyoming moose tested from 2003 to 2005 was positive (WGFD, unpubl. data 2005).

In confined situations prevalence can be much higher. In a small captive elk herd, 71% (5 of 7 animals) died of chronic wasting disease (Miller, Wild, and Williams 1998). In a captive mule deer herd, more than 90% died or were euthanized due to the disease (Williams and Young 1980). Few game farm prevalences 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 occurs between animals and from contaminated environments to animals (Williams and Miller 2002). Earliest detection of the prion agent is in the gut-associated lymphoid tissues (Sigurdson et al. 1999), and the pathogenesis appears to be related to uptake by these tissues

Map

Chronic Wasting Disease in North America
(2002–2006)

Map

Chronic Wasting Disease in Wyoming (2003–2005) from oral ingestion of the prion agent. Because of this pathway, and the ability to detect the CWD prion in gut-associated lymphoid tissues, shedding via the alimentary tract (feces or saliva) appears to be a likely method for dissemination into the environment (Williams, Miller, et al. 2002). However, no one has determined the pathways by which the CWD prion exits the host. 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 (Madson 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).

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 (B. L. 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 was estimated to represent less than 1% of the herd (WGFD 2003). From 2000 through 2005 researchers monitored radio-collared wolves and tracked wolves in snow, documenting 231 ungulates, including elk, killed in winter by wolves in Bridger-Teton National Forest, Grand Teton National Park, and on state-managed feedgrounds in the Gros Ventre River drainage (Jimenez et al. 2006). Of the 231 animals killed, 97% (225) were elk and 3% (6) were moose. Of the 225 elk killed by wolves, 47% were calves, 43% cows, and 10% bulls. The average age of adult elk killed was 9.3 years; the oldest was 23.

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, when wolf activity increased and one pack of 3–4 wolves killed 18 elk. In 2005-6 two packs (totaling 16–20 animals) wintered on the

Map

Existing Elk Hunting Areas

refuge. There were 63 documented wolf-killed elk, which represented 0.9% of elk classified during the winter count. Wolf predation accounted for 29% of total refuge mortalities. An accurate count of wolf-kills is not available for the 2006–7 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). In 2005 researchers extended their field season throughout the year to determine wolf food habits in seasons other than winter (Jimenez et al. 2006) and located 90 ungulate carcasses, 93% (84) of which were elk and 7% (6) were moose. Of the 84 wolf-killed elk, 47% were calves, 39% cows, and 14% bulls.

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 1990). Preliminary results from a northern Yellowstone elk calf mortality study indicated that during 2003 and 2004 bears accounted for 55%–60% of tagged calf mortalities, and coyotes and wolves each accounted for about 10%–15% (Barber, Mech, and White 2005). 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.

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 do so 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 98).

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 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 (J. 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 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 [MFWP] 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 elk numbers have ranged from less than 9,000 to about 19,000 since the 1970s. The annual winter count typically changes 10%–20% from year to year, but sometimes by as much as 30%–40% (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 per 100 cows to a low of 14 calves per 100 cows in 2002. However, calf recruitment in Yellowstone varies widely from year to year, ranging from 14 to 48 calves per 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 2005–6 the Jackson elk herd was estimated at approximately 12,855, about 2,000 elk over the objective of 11,000. 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.

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.

Before wolves recolonized the southern Greater Yellowstone Area, elk calf-to-cow ratios in the Gros Ventre River drainage decreased from 1989 through 1999; the average over this 10-year period was 28.8 calves per 100 cows (Jimenez et al. 2006). These ratios have averaged 25.5 calves per 100 cows.

The calf-to-cow ratios on the Gros Ventre feedgrounds and the refuge appear to fluctuate regardless of whether wolves are present (see Figure 4). 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, rose in 2003–4 and again in 2004–5 (in this year to a ratio higher than during the 1989–99 period, with 32 calves per 100 cows), and then decreased again in 2005–6. The National Elk Refuge ratio has also been variable, rising, declining, and then rising again from 2000–2001 through 2005–6. 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.

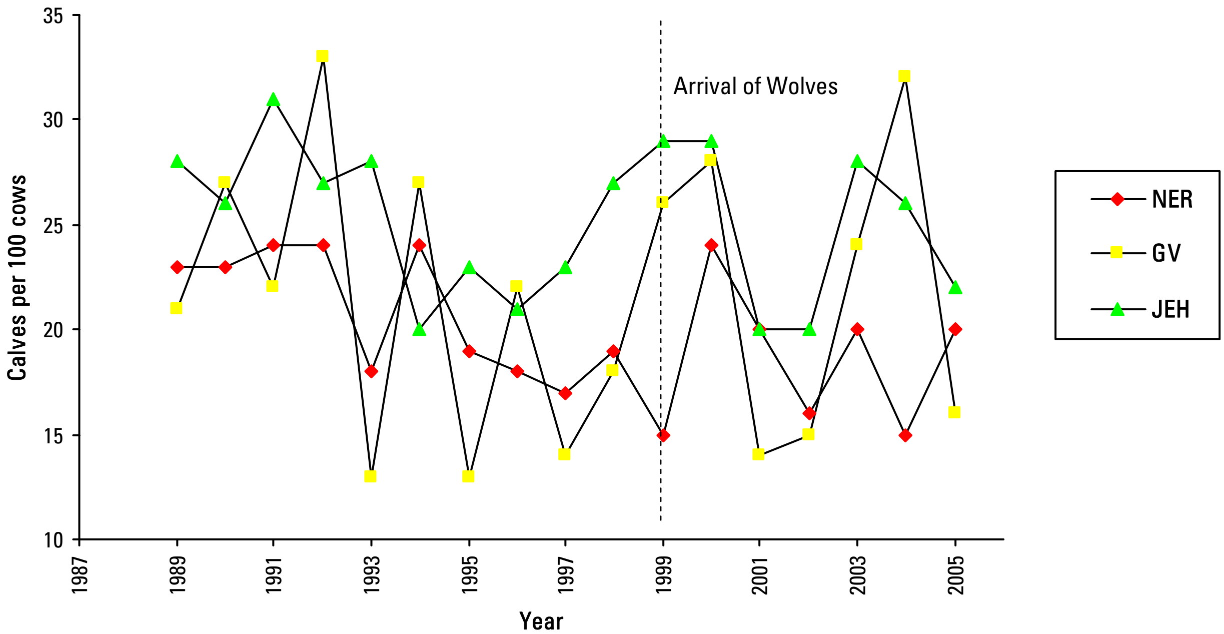
FACTORS AFFECTING CALF-TO-COW RATIOS

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. L. 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 the 1991 study by DelGiudice, Mech, and Seal, which indicates that nutritional deprivation was related to high ungulate densities, deep snow, and declines in calf-to-cow ratios from early to late winter.

FIGURE 4: 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

NOTE: Years are biological years. Ratios are based on counts made during early winter of the following calendar year.

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 birth weight 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 at a nutritional 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). Winter supplemental feeding has been found to increase survival of Jackson elk calves (<1 year old) (Smith and Anderson 1998).

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. During the late 1990s cooler April temperatures and larger elk numbers coincided with declining weight gains and lower survival of calves in the Jackson elk herd (B. L. Smith et al. 2006). 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 (J. 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 (J. 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). Indiscriminant 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 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. L. Smith, pers. comm. 2002).

BULL AGE STRUCTURE AND BULL-TO-COW RATIOS

Some studies indicate that elk populations exhibit lower pregnancy rates when there are few older bulls and when much of the breeding is performed by less efficient yearling bulls (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, Vore, and Carlsen 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 the discussion under "Predators and Scavengers," beginning on page 98, 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 and Dundas 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

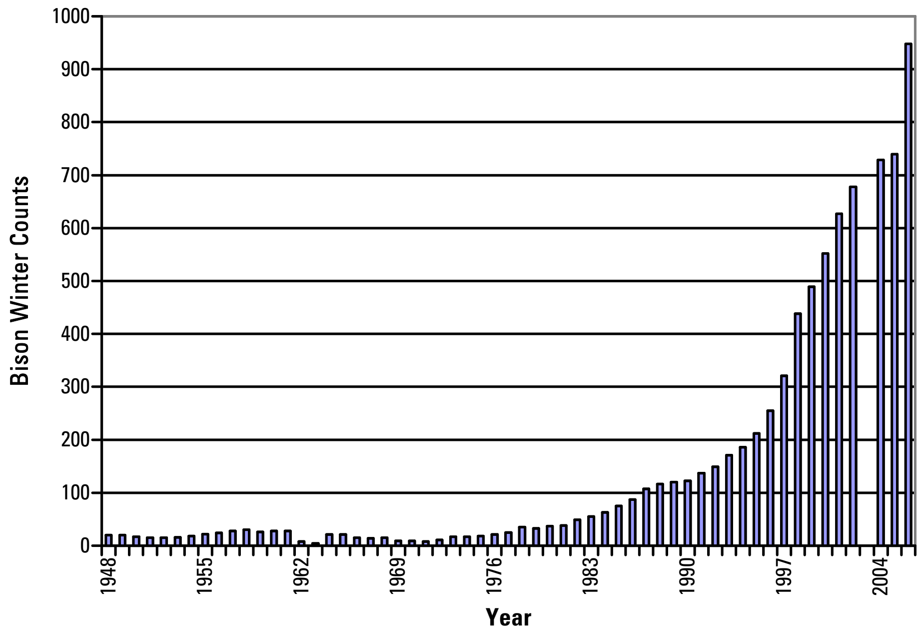
Since discovering the elk feedlines on the refuge in 1980, the bison herd has greatly increased in size (see Figure 5), and the U.S. Fish and Wildlife Service has both culled them (taking 16 bison) and conducted a special permit hunt (taking 19 bison) in an effort to reduce it. However, as previously discussed, 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 2006, the herd numbered 948. A study was initiated in 1997 to determine more about bison demography, reproduction, and effects of brucellosis on the population.

FIGURE 5: 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 has jurisdiction over wildlife on the elk refuge (16 USC 668dd) and the National Park Service over wildlife in the park (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 they 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 northward in the spring.

Map

Jackson Hole Bison Herd Seasonal Ranges

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 summers 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 as 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, and Hunter-Talbot areas 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 age (GTNP unpubl. data), while males do not usually become part of the active breeding

Bison calf.

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, with a slight favoring of 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). Herd composition estimated from the February 2006 classification was 60% adults, 9% yearlings, 19% calves, and 6% unclassified. Sex and age composition was estimated at 75 bulls per 100 cows and 45 calves per 100 cows (GTNP unpubl. data).

OTHER FACTORS INFLUENCING BISON 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 66).

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 2005, hunters harvested 225 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 prey 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).

Although some researchers have investigated a tentative relationship in cattle between a gene, NRAMP1 (now known as SLC11A1 [Derr et al. 2002) and natural resistance to brucellosis, there is no apparent association in bison (Halbert, pers. comm. 2006).

Some genetic analyses have been done on the Jackson bison herd, primarily focused on gene diversity and introgression for cattle genes. In limited analyses completed to date (39 bison sampled), no evidence was found for cattle genetic introgression. Analysis of additional samples would add to confidence in this negative finding (Halbert, pers. comm. 2006). Management would continue to focus on maintaining genetic diversity, not specific genes, because unknown effects could be obtained by the selection of closely linked traits.

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, or prime breeding-age bulls) can negatively influence the genetic integrity and viability of a population. For the purposes of this 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).

A recent modeling report (Gross et al. 2006) analyzed genetic diversity retention in several NPS bison herds and similarly concluded that 400 was the minimum herd size at which bison would be able to meet a long-term goal of achieving a 90% probability of retaining 90% of genetic heterozygosity for 200 years. (Heterozygosity is defined as the proportion of individuals in a population that are heterozygous, i.e., having more than one version of a gene at a chromosome locus.) Because results were based on simulations of precise management scenarios, the authors cautioned that management under field conditions should be designed to accommodate natural variation and advised retaining a larger herd size. They also suggested that herd sizes must be as large as 1,000 for a 90% probability of retaining 90% of allele diversity for 200 years. However, at this time this recommendation has not received wide support, and there is no consensus about if or how it should be incorporated into public herd management plans.

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.

The following species would not be affected by the management plan: lynx, wolverines, river otters, fishers, American martens, and whooping cranes.

The "Biological Opinion," which documents the effects of implementing this plan, is included in Appendix E.

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. There are currently six known wolf packs in the Jackson Hole area and the Gros Ventre River drainage, totaling approximately 54 wolves.

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 1998–99. 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 through 2005 except for 2000. The Teton pack currently has 10 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 River 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. In 2005–6 two packs (totaling 16–20 animals) wintered on the refuge.

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. L. 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 population 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 had not been studied in any ecosystem until recently. In 2005 researchers expanded their field season throughout the year to determine wolf food habits in seasons other than winter (Jimenez et al. 2006). This research is ongoing.

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 on the refuge since 1994. The ecosystem's grizzly bears number an estimated 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 *(Haliaeetus leucocephalus)* is currently listed as federally threatened and is protected under the Migratory Bird Treaty Act (16 USC 703) 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 (Swenson, 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.

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 on the National Elk Refuge.

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 are primarily winter residents that migrate from the Gros Ventre Mountains. From November to May 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). In 2004, 30 bighorn sheep were seen, and in 2005, 31.

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. L. 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 pronghorn, elk, and bison occupy the same habitats 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 winters from 2001–2 to 2004–5; eight were seen in the winter of 2005–6. 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 River 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 the number increases 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 the 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, and 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.


Coyote and magpies scavenging on an elk carcass.

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 opportunistically on wild horses, beavers, porcupines, raccoons, and hares, 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 made 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. 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 River 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.

Black Bears

Black bears are common in Grand Teton National Park and Bridger-Teton National Forest, but rarely occur on the National Elk Refuge. Inhabiting forested areas, they feed 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. L. 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 refuge and the park 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).

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

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 typically feed 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 mammals in the Jackson Hole area are abundant and include ground squirrels, mice, voles, shrews, chipmunks, tree squirrels, muskrats, northern pocket gophers, pikas, cottontails, and snowshoe hares. Suitable habitat is the most important factor influencing the distribution and abundance of small mammal populations. Many small mammals occupy a wide variety of habitats, while others have specific requirements that limit their distribution (see Table 10). In general, most species prefer more mesic environments. Edge habitats generally support more species than interior habitats.

TABLE 10: SMALL MAMMALS THAT OCCUR IN VARIOUS HABITATS

Habitat	Common Mammals
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 four 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 among the 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 the 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

Woodpecker on the National Elk Refuge.

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 (E. M. 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 observed 25 bird species in riparian woodland habitats and 54 species in upland aspen habitat in the Jackson Hole vicinity (E. M. Anderson 2002).

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 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 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 (E. M. Anderson 2002). His results are summarized below:

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) a lower density of aspen saplings, (7) a lower proportion of the stands with saplings, (8) higher rates of sucker browsing, (9) a lower proportion of suckers, (10) more damage to bark, (11) a higher density of dead trees, and (12) a higher proportion of the stands with 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 emphasized that recruitment of aspen and willow was extremely rare both on the National Elk Refuge and near the WGFD Gros Ventre feedgrounds (E. M. Anderson 2002).

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. The maximum number of males counted on the refuge was 18 in 2005 and 30 in 2006. The north end of the refuge contains valuable breeding and nesting habitat for the Jackson Hole sage grouse population.

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 that sage grouse population growth in the park was essentially stable, 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 would be 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 population 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 on refuge wetlands, but most waterfowl and shorebird species in the Jackson Hole area are seasonal migrants. Rocky Mountain Canada geese nest on 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.

Trumpeter swan nesting on the National Elk 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 River 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, 2004b). There are few Columbia spotted frogs in the Flat Creek drainage, but they are widespread in the Gros Ventre River 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, and boreal toads are particularly susceptible. The boreal toad populations of southern Wyoming and Colorado are candidates for listing as federal endangered species 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 2004b). 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 occupied Jackson Hole. Native Americans living on surrounding lands used this neutral valley primarily during the warm months. 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. This area, the upper Snake River plains, received higher rainfall, providing adequate grasses and forage for bison to exist. Bison were by far the greatest food resource, providing an endless supply of food, clothing and shelter materials, and weapon and tool products.*

* 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.

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 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 chose to stay on the Fort Hall Reservation.

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.*

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.

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 historical 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 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 2003a).

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; C. 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.

Bison played no role in early settlers' lives due to the fact that bison had been extirpated from the valley by the 1840s.

CULTURAL RESOURCES

ARCHEOLOGICAL RESOURCES

Limited but documented archeological evidence indicates 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 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. Evidence of permanent settlements by Native Americans has not been found 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,

Historic photo of Jackson, ca. late 1800s.

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 River 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 (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

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). Bicyclists in this area of the park also risk potentially dangerous encounters with bison. A Kelly resident told of several incidents of bison charging him and other bicyclists along the Gros Ventre Road in 2005 and 2006; no one was injured in these encounters (Kerasote, pers. comm. 2006).

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, a hunter safety course must be completed, and hunters must have a hunter safety certificate. Firearms must be carried unloaded, and they must be dismantled or cased while in transit. Hunters must wear fluorescent orange exterior garments, as prescribed by state regulations, while hunting on the refuge (USFWS 2002c), and they 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 (see NPS and WGFC 2002). Clearly defined hunting areas and shooting hours also help prevent accidental injuries.

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 hunting 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 the exposure risk.

Humans are susceptible to bovine tuberculosis, but infection is fairly rare (Thorne et al. 2002). This disease 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 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 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

Chronic wasting disease is not known to be a human health risk. Thus far, no evidence of human infection with the CWD agent has been found, and ongoing research is attempting to definitively determine whether or not humans can be infected. The risk to human health appears to be extremely small, if present at all (Belay et al. 2004); however, the researchers noted that the species barrier may not prevent transmission completely, and that long-term surveillance for human prion diseases continues to be important. Kong et al. (2005) used transgenic mouse models to determine that a substantial species barrier exists between humans and elk. To be safe, the Centers for Disease Control and Prevention and wildlife officials in several states recommend that hunters not consume meat from animals that appear sick or test positive for chronic wasting disease.

People hunting in CWD-infected herds should use common sense measures to reduce risk in case transmission could occur. These measures include (1) not harvesting an animal that appears 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 (Williams, Yuill, et al. 2002).

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.

PUBLIC USES

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 Koontz 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 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 Koontz 2004).

TABLE 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 Koontz 2004.

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

Grand Teton National Park

Grand Teton National Park had an average of 2,458,886 recreational visits from 1991 to 2001. In 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 Koontz 2004). For local visitors, sightseeing and hiking were the most frequent activities, while viewing bison ranked fifth and viewing elk sixth (Loomis and Koontz 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 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 Koontz 2004).

HUNTING / PARK ELK HERD 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 permits 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

Hunters on the National Elk Refuge.

average of 312 elk 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 River drainage. Some wildlife managers believe that in the past the eastern migratory segment of the herd (those elk that migrate east of Grand Teton National Park during fall) were over-harvested, largely because of increased road and other access on national forest lands. At the same time, western migratory segments were believed to have grown, decreasing hunting opportunities as more elk migrated through protected park areas. Concerted attempts to

Map

Landownership in Western Wyoming

increase numbers in the eastern segments and to reduce numbers in the western segments by regulating hunting seasons and harvest strategies since the late 1980s to the present have met with some success. Nevertheless, the elk reduction program in the park and hunting on the refuge can affect hunting opportunities and numbers of elk outside these areas. Consequently, refuge and park personnel work closely with the Wyoming Game and Fish Department in the development of annual hunting quotas and regulations, so that management of the entire herd is based on a holistic framework that includes all land and wildlife management responsibilities.

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 additional analysis of the impacts.

Bison hunting is not allowed in Grand Teton National Park.

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, 2005, there were a total of 7,000 cattle on ranches and farms in Teton County, Wyoming, with a value of $7.1 million, which is less than 1% of the state total (the statewide average per head is $1,020, as of January 1, 2005; Wyoming Agricultural Statistics Service 2005). In 2002 there were 4,907 cattle on 35 ranches in Teton County, including 8 ranches with 200 or more cattle each. In 2002 the value of all cattle sold in Teton County was $5.3 million.

Table 12 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.

As shown in Table 12, 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 who 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.

As of January 1, 2002, there were no breeding sheep on Teton County farms or ranches. The most recent census data show that there were no farms with swine inventory and that there were five farms with sheep inventory in Teton County in 2002. 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.

TABLE 12: 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 and 2006.
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.

BRUCELLOSIS

Brucellosis has been 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

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Map

Bison Calving Area and Livestock
Allotments

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 regulation, Wyoming law required that test-eligible cattle and bison test negative for brucellosis no more than 30 days prior to a change of ownership. Prior to the downgrade in status (effective February 13, 2004), cattle in Wyoming were not required to be tested for brucellosis.

A state 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 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. After complying with testing and surveillance requirements and applying for class-free status reinstatement, Wyoming was reinstated as class-free in September 2006.

Although difficult to assess, the brucellosis outbreaks do not appear to have had a major adverse impact on market prices for Wyoming cattle. Prices 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 shown a general upward trend, notwithstanding the several brucellosis discoveries in the state in 2004. Prices for the first nine months of 2005 were well above those for the same period in 2003, a time when Wyoming's brucellosis status was class free. 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 necessitated the quarantine of approximately 15 contact and adjacent herds in that state. Furthermore, approximately 935 cattle in Wyoming (280 in the infected herd near Boulder, Wyoming, and 655 in the Teton County herds) were 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 have not had a crippling effect on the cattle industry statewide, given that brucellosis testing and testing-related costs represent only a small portion of annual production costs. Based on a test cost of $5.50 (after a $3.50 reimbursement by the State of Wyoming) and hidden costs of $6, total brucellosis testing and testing-related costs of $11.50 per animal represent only 1% of annual per animal production costs.** This is not to suggest

* "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 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 six-month intervals. A change from class-free to class A status meant that Wyoming's dairy producers 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.

** 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 United States (which includes western Wyoming) totaled $1,099.48 in 2004.

that all producers in Wyoming have experienced the same relative impact, as the financial circumstances of individual producers vary. Even before the downgrade in status, some producers in Wyoming performed brucellosis tests voluntarily to enhance the value of the cattle they sold. Assuming that an additional 100,000 to 150,000 head have to be tested annually, it is estimated that cattle producers in Wyoming will have to spend an additional $1.2 million to $1.7 million per year to cover the costs of the required animal testing.

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