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HISTORIC AND RECENT DISTRIBUTIONS OF ELK IN NEBRASKA

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ABSTRACT—Elk (*Cervus elaphus*) were historically found throughout North America but were extirpated from Nebraska and much of the Great Plains in the 1880s due to consumptive uses by settlers, miners, market hunters, and others. Elk began to reappear in Nebraska in the 1950s and 1960s, and established a stable, nonmigratory population that currently consists of seven herds and an estimated 1,400 individuals throughout western and central Nebraska. The reappearance and subsequent persistence of elk in Nebraska suggests there is adequate habitat to support a self-sustaining population. The general movement of elk eastward may lead to an eventual statewide distribution, and populations being established in states to the east and south of Nebraska, where elk populations were historically present and suitable habitat still exists. We examined published historic accounts, museum and archeological records, and current literature to determine historic and current distribution of elk in Nebraska and the Great Plains.

Key Words: *Cervus elaphus*, distribution, elk, expansion, extirpation, Great Plains, Nebraska

INTRODUCTION

Before the arrival of Euro-American settlers in North America, elk (*Cervus elaphus*) were the most widely distributed species of deer on the continent (Murie 1951; Gunderson 1976). Its geographic range extended from southern Canada to northern Mexico and from the Pacific to Atlantic coast (Wyman 1868; Bailey 1896; Stone 1908; Murie 1951). By the mid-1800s, however, numbers of elk were declining in the eastern United States. Baird (1852) stated, "At the present time, in the eastern parts, it [elk] is only found in a few counties of Pennsylvania . . . where indeed their numbers are decreasing day by day; a few are known to exist in . . . western Virginia; it is only as we proceed farther west that they present themselves in numbers." The primary cause of the extirpation of elk in the eastern United States was market and subsistence hunting (O'Gara and Dundas 2002).

Elk were distributed throughout the Great Plains, but with westward movement of settlers, miners, and market

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hunters occurring throughout the mid- and late-1800s, elk were extirpated from states such as Iowa, Missouri, Kansas, South Dakota, and Nebraska (Murie 1951). Elk disappeared from the Great Plains at about the same time as bison (*Bison bison*). "Westward expansion, more efficient rifles, transcontinental railroads that provided access and a means of hauling animal parts and a booming market for meat, furs, hides and ivories resulted in bison, elk, deer, pronghorn and other wildlife being rapidly reduced in numbers" (Stalling et al. 2002). Information on the natural history and historic range of elk is important for understanding population expansion and necessary habitat requirements for continued persistence. Historical records, although often incomplete, serve a vital link in determining past population levels and distributions of elk in the Great Plains through eyewitness accounts.

Currently, elk are expanding eastward into their historic range, due in part to natural movements and translocation efforts by state wildlife agencies. Elk reintroductions have been successful in Pennsylvania (1913), Michigan (1918), Arkansas (1981), Wisconsin (1995), Kentucky (1997), Tennessee (2000), Ontario and North Carolina (2001). Reintroduction studies have been conducted in New York, Virginia, West Virginia, and Illinois (Rocky Mountain Elk Foundation 2008).

Unfortunately, historical information on the distribution of elk in Nebraska is not readily available because the size and locations of populations were not recorded due to lack of status as a game animal until 1995. In addition, information regarding the current distribution and abundance of elk in the Great Plains is not readily available. The objective of our research was (1) to determine the historical distribution of elk in Nebraska and in the Great Plains, (2) to identify change and causes of change in the distribution of elk in the Great Plains, (3) to report on a specific case of elk distribution in the Pine Ridge of Nebraska from 1994 to 1997, and (4) to discuss the management implications of future redistribution of elk in Nebraska.

METHODS

Study Area

We define the Great Plains as the area west of the Mississippi-Missouri valley and east of the Rocky Mountains, stretching from the southern parts of Manitoba, Saskatchewan, and Alberta in Canada south to central Texas (Wishart 2004), with Nebraska located near the center of the Great Plains. Wolcott (1926) described the historic climate of Nebraska as having hot summers and mild, dry winters, with sudden and severe changes. The five biotic regions of Nebraska include Missouri River bluffs, tallgrass prairie, sandhills, plains, and coniferous woodland. Currently over 9 million ha of cropland are distributed across Nebraska (USDA-NASS 2004).

The Pine Ridge, which lies in the northwestern corner of Nebraska, is approximately 160 km long and 1 to 8 km wide, covering 120,000 ha (Fig. 1). Two distinct study areas were used to address objective 3: the Hat Creek area, located between Crawford and Harrison in Dawes and Sioux counties, respectively, and the Bordeaux Creek area, located east of Chadron in eastern Dawes and western Sheridan counties. The two study areas were determined from annual home ranges of 21 radio-marked elk (Cover 2000).

The Pine Ridge is dominated by privately owned land interspersed with public land managed by the U.S. Forest Service, Nebraska National Forest, and the Nebraska Game and Parks Commission (NGPC). The percentage of privately owned land and public land in the study area was 94% and 6%, respectively. The Pine Ridge is dominated by ponderosa pine (*Pinus ponderosa*) forests interspersed with grassland pastures consisting of big and little bluestem (*Andropogon gerardii* and *Schizachyrium scoparium*), Kentucky bluegrass (*Poa pratensis*), and brome grass (*Bromus* spp.). Cropland areas consisted of winter wheat, alfalfa, and oats (Cover 2000). The Hat Creek area consisted of 47% ponderosa pine (14% burned in 1989), 50% pasture, and 3% cropland. The Bordeaux Creek area consists of 51% ponderosa pine, 46% pasture/grasslands, and 3% cropland (Stillings 1999). We classified habitat using aerial photography, United States Geological Survey 1:24,000 maps, and ground truthing to ensure accuracy.

Literature Review

We examined 58 published historic accounts, reviews, and summaries of the exploration and settlement of the Great Plains and Nebraska during the 19th and 20th centuries and 25 published manuscripts on current management and ecology of elk. We integrated published records of the distribution of elk in the Great Plains to gain specific knowledge of the historic distribution of elk in Nebraska. Big game biologists from all states in the Great Plains were contacted in January 2008 to determine current populations and distributions of elk.

We conducted an extensive search of prehistoric, archeological, and museum records for elk in Nebraska. We

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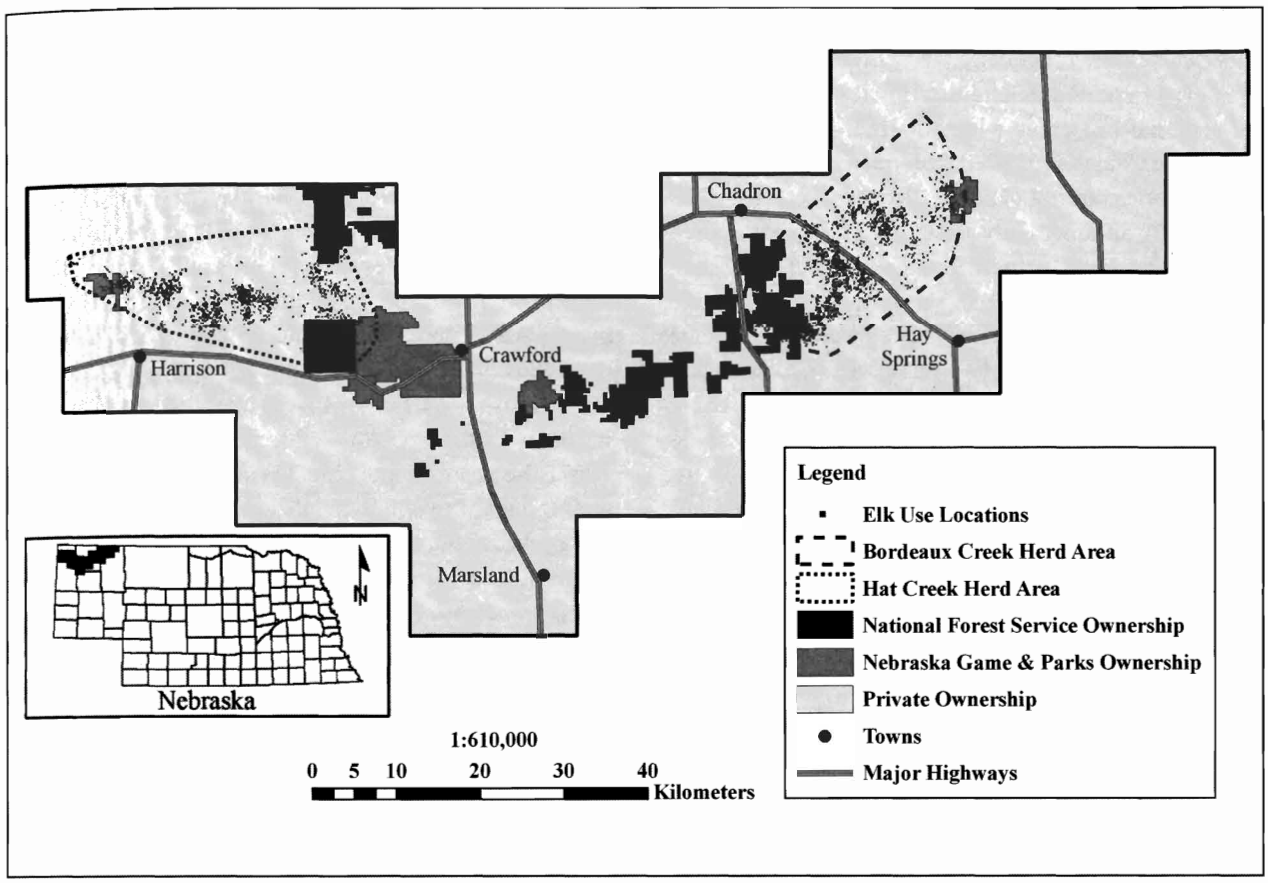

Figure 1. The area of the elk study in the Pine Ridge of northwestern Nebraska, 1994-97, with landownership classification.

queried "*Cervus*" and "elk" on FAUNMAP, an electronic database derived from a published literature review of specimens known to have an age of less than 40,000 years (Faunmap Working Group 1994). Unpublished reports and specimens of unknown age were not included in the database. The journals of the 1804-6 expedition of Lewis and Clark were combined in a date- and keyword-searchable database titled "Journals of the Lewis and Clark Expedition Online" (University of Nebraska–Lincoln [UNL] 2005). The database of the combined journals of Clark, Lewis, Ordway, Floyd, Gass, and Whitehouse was queried for "elk." The resulting journal entries were examined for geographic locations to determine where and when elk were documented, particularly in present-day Nebraska.

Capture, Radio Telemetry, and Data Collection

We captured 21 free-ranging female elk in the Hat and Bordeaux Creek areas (Fig. 1) using helicopter net-gunning (Helicopter Wildlife Management, Salt Lake City, Utah) and alfalfa-baited modified Clover traps (Clover 1956) in March, August, and December 1995 and in March 1996. We equipped all captured elk with mortality-sensing 150- to 151-MHz radio-collars (Advanced Telemetry Systems, Insanti, MN) and two sets of alphanumeric ear tags. We placed 11 and 10 collars on elk in the Hat and Bordeaux Creek study areas, respectively. During April 1995 to August 1997 we located elk by radio telemetry, using vehicles equipped with nine-element Yagi directional antennas (Cushcraft Corporation, Keene, NH) and Telonics Model TR-2 receivers (Telonics, Mesa, AZ) at random times throughout the day and night to ensure an accurate representation of individual home ranges and movements. We collected two to three azimuths at fixed receiver locations and calculated triangulations to locate collared elk. Only locations with error polygons less than 10 ha were recorded. We used the closest possible receiver locations to each animal and attempted to achieve a 90° bearing intersection between two receiver sites. We recorded visual observations when possible, especially during the early morning or evening hours when

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elk were leaving feeding or bedding areas. We used MIPS 2.0 (MicroImage Processing, Inc., Lincoln, NE) to plot locations of elk and generate estimates of home ranges and seasonal use areas with a harmonic mean method (Dixon and Chapman 1980). We divided home ranges into five categories: spring (March 1-May 14), calving (May 15-June 30), summer (July 1-August 31), breeding (September 1-October 31), and winter (November 1-February 28). We identified calving areas when pregnant females isolated themselves from the herd several days before calving (Craighead et al. 1972) and remained stationary with their calf for 10–21 days (Knight 1970). We evaluated microhabitats of calving and wintering sites by locating elk during these periods and measuring associated habitat variables. We used aerial photographs provided by the U.S. Forest Service and a geographic information system (ArcInfo) to generate land-cover maps of the study area including the habitat variables ponderosa pine forest, grassland, cropland, rangeland occupied by cattle, riparian areas, and other. All field aspects of this project were approved by the University of Nebraska–Lincoln (UNL) Institutional Animal Care and Use Committee (IACUC #94-09-075).

RESULTS AND DISCUSSION

Early Records of Elk in Nebraska

Elk remains have been reported from late Pleistocene at archeological sites in Nebraska, indicating that the species has had a long history in the state. Prehistoric records place elk in Nebraska as early as the Middle Holocene (3,500 to 8,500 years before present) and as recently as the Post-Columbian (0 to 550 years before present, Faunmap Working Group 1994). Late Pleistocene remains of elk have been recovered from gravel-pit deposits along the Nemaha River in Pawnee County and Meadow, Sarpy County, in the Platte River valley (Schultz 1934, Fig. 2). Elk remains and artifacts also have been reported from a number of archeological sites in Nebraska; however, it must be noted that remains from these sites may have been transported long distances as food items or as tools and decorative objects. Archeological records place elk in nine counties in Nebraska at 12 different sites (Gilder 1907; Champe 1946; Faunmap Working Group 1994). The oldest of these sites is Logan Creek (25BT3) in Burt County, which dates to between 6,600 to 8,125 years old (Semken and Falk 1986). Remains from the Niobrara Railroad Bridge site (25KX275) in Knox County were between 1,000 and 2,000 years old (Howard and Gant 1966).

All of the remaining archeological sites in Nebraska where elk remains have been identified were occupied within the last 1,000 years. A minimum of six elk specimens were identified from five sites (Brown site, 25NC8; Cunningham site, 25NC10; 25NC12; 25NC13; Burkett site, Dunlevy and Bell 1936, Semken and Falk 1986) in Nance County. At the Hulme site (25HL28) located in the Platte River valley in western Hall County, Bozell (1991) commented on the relative rarity of elk: "Deer and pronghorn material constitute 66.2% of the identified mammals and bison and wapiti 2.4%" (Fig. 2). In eastern Nebraska, elk remains were identified from a site in northern Douglas County (Ponca Creek district; Gilder 1907), the Schuyler site (25CX1) in Colfax County where a minimum of two individuals were present (Bozell et al. 1982), the Shulte and Wiseman sites where antlers were found in Cedar County (Cooper and Bell 1936), and several sites in Cass County (Bell and Gilmore 1936). Roper (1989) also discovered remnants of elk bones from a protohistoric Pawnee site in eastern Loup County along the Calamus River in the central part of the state. In southern Nebraska, the remains of a single individual elk were represented at the Shipman site (25WT7) located between Red Cloud and Guide Rock along the Republican River in Webster County (Mick 1983; Semken and Falk 1986), and an elk represented by one antler fragment and two molar fragments was discovered at the White Cat Village site (25HN37), near Alma in Harlan County. Finally, in the panhandle the remains of two individual elk were identified from surface deposits in Ash Hollow Cave in southeastern Garden County just across the North Platte River from Lewellen (Champe 1946) and at the Sweetwater Culture Complex in Sherman County where elk antlers were found (Champe and Bell 1936).

There are very few pre-1900 elk specimens from Nebraska in museum collections, and only two of these have locality data that are precise enough to be informative. The National Museum of Natural History has a single specimen from along the Republican River, near Red Cloud, Webster County (Bryan 1857), taken by members of a surveying party under the command of Lt. F. T. Bryan on October 4, 1856. The other elk specimen from this time period was taken near the present town of Schuyler, Colfax County, in 1869 (Museum of Vertebrate Zoology, University of California, Berkeley, 103405).

The historic distribution of elk in Nebraska has been documented as statewide (Cary 1905; Jones 1964). Swenk (1907) stated, "Originally this fine animal [the elk] was found over the whole of Nebraska abundant equally in the thinly wooded Missouri [River] region, the open

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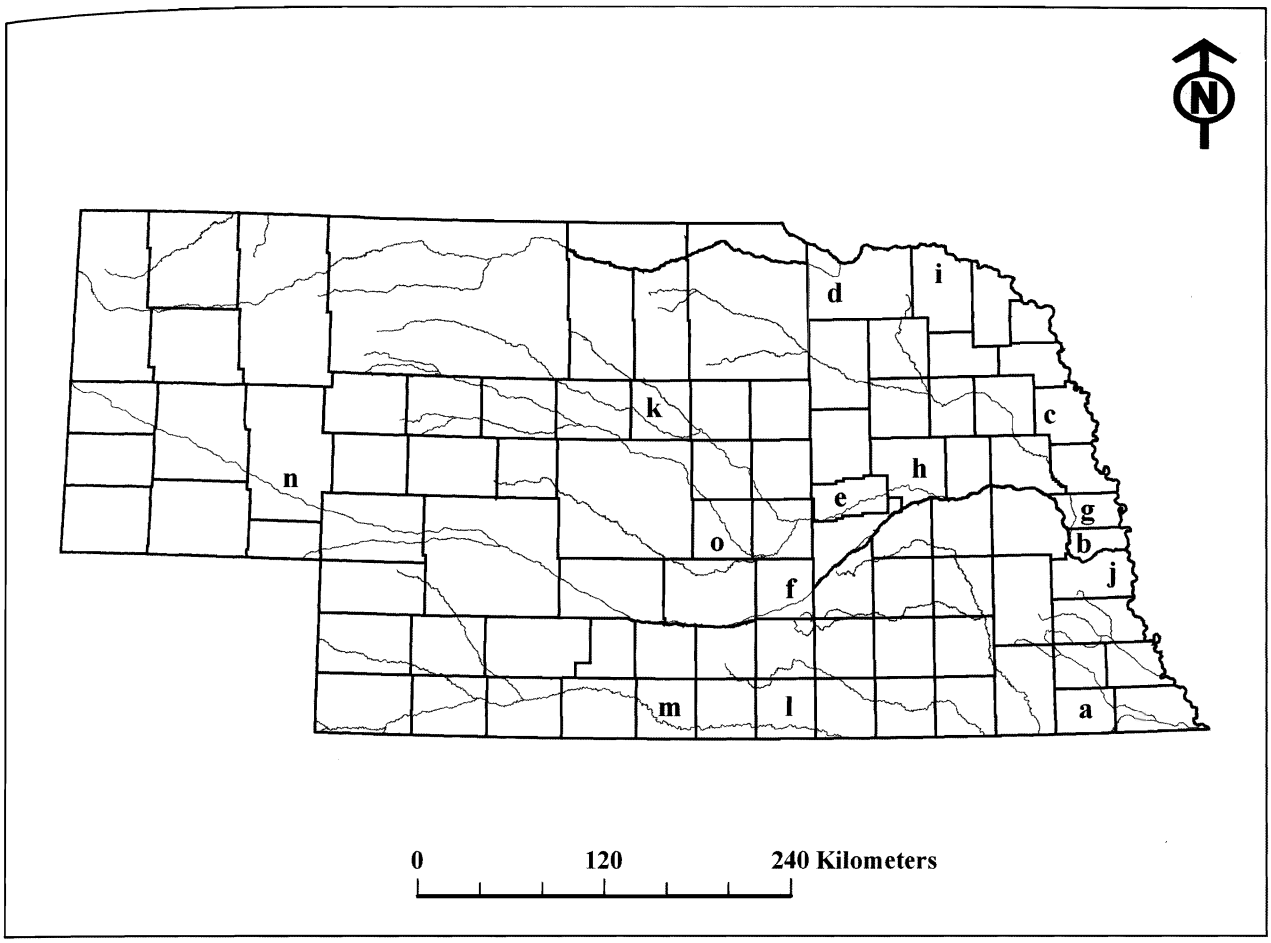

Figure 2. The location of archeological remains of elk in Nebraska by county. **(a)** Pawnee (Schultz 1934); **(b)** Sarpy (Schultz 1934); **(c)** Burt (Semken and Falk 1986); **(d)** Knox (Howard and Gant 1966); **(e)** Nance (Dunlevy and Bell 1936; Mick 1983; Semken and Falk 1986); **(f)** Hall (Bozell 1991); **(g)** Douglas (Gilder 1907); **(h)** Colfax (Bozell et al. 1982, UC Berkeley); **(i)** Cedar (Cooper and Bell 1936); **(j)** Cass (Bell and Gilmore 1936); **(k)** Loup (Roper 1989); **(l)** Webster (Bryan 1857, Mick 1983, Semken and Falk 1986); **(m)** Harlan (Adair and Brown 1987); **(n)** Garden (Champe 1946); **(o)** Sherman (Champe and Bell 1936).

sandhills, and the rugged Pine Ridge and Bad Lands." The Pawnee, who inhabited eastern Nebraska before the arrival of Euro-American settlers, had a unique approach to hunting elk. "If the Pawnees discovered that deer or elk were in a piece of timber, they would surround it, alarm the game, and keep them from breaking through the line of men. The animals would run round and round in a circle until exhausted, then the Pawnees would close in, and kill them with their arrows" (Grinnell 1961).

The first recorded sightings of elk in Nebraska came from the expedition of Lewis and Clark in 1804-6 (Moulton 1986, 1987, 1993; UNL 2005). The explorers observed elk on at least 12 occasions while traveling northward on the Missouri River along the eastern edge of Nebraska in 1804 and three times upon their return in 1806 (Fig. 3, Table 1). John Bradbury observed elk on numerous occasions in 1811 while traveling along the Missouri River in eastern Nebraska (Bradbury 1819; Table 2). While traveling up the Missouri River in 1811, Henry Brackenridge noted they "saw several elk and deer, without being able to approach them" (Brackenridge 1814). Members of the expedition of Maj. Stephen Long noted bison, antelope, and elk along the Elkhorn and Platte rivers in 1819-20. They recorded in their journals that young men of the Omaha tribe "are employed in hunting within the distance of seventy or eighty miles around, for beaver, otter, deer, muskrat, elk, etc." (James 1823; Fuller and Hafen 1957). As naturalist John Townsend traveled westward along the Platte River in central Nebraska in 1834, they encountered "a large band of elk" that galloped past the group causing "a great disturbance among their horses." Later in the trip, Townsend noted game was scarce (Townsend

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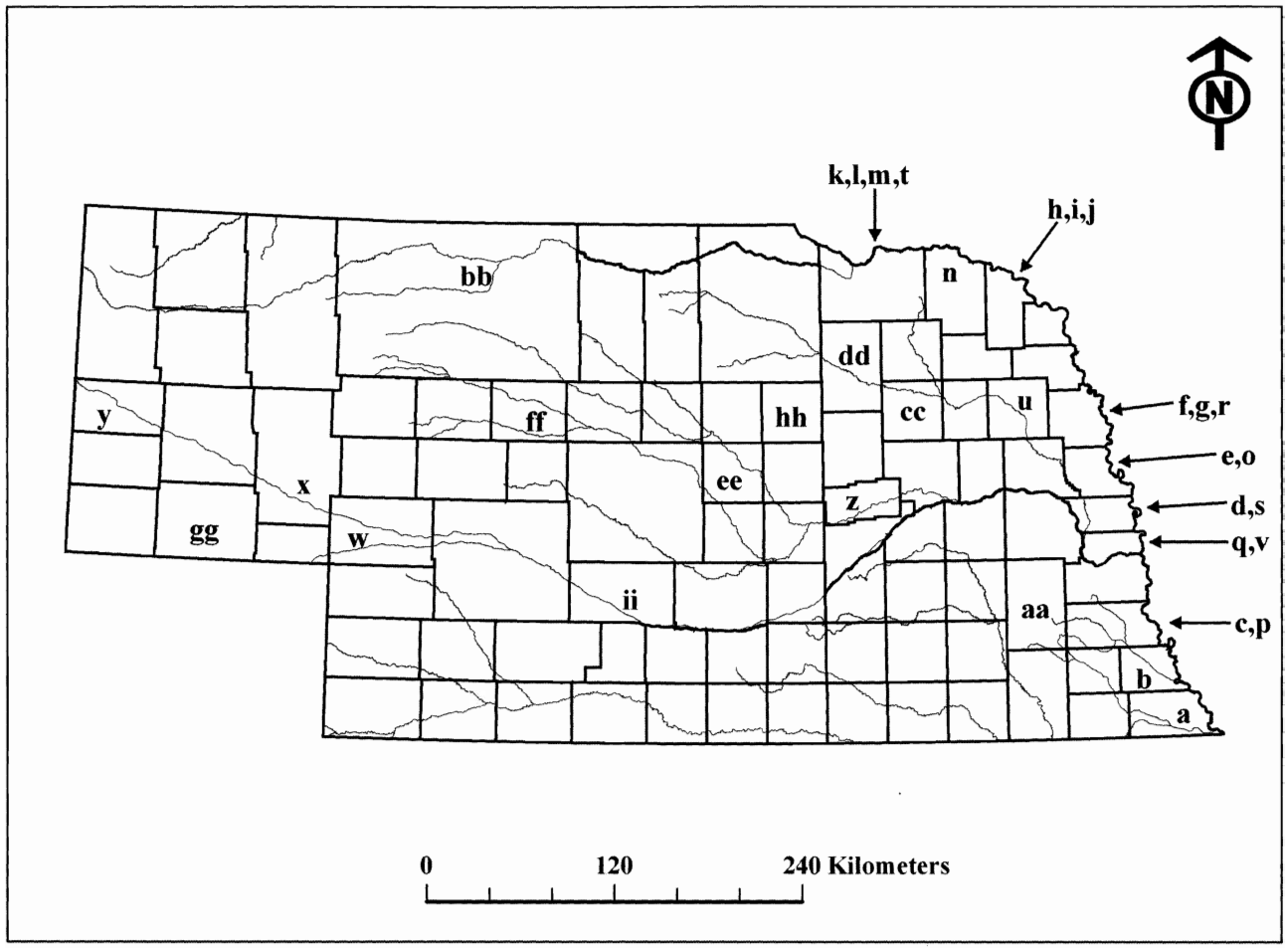

Figure 3. The location of observations and historic records of elk in Nebraska by county. [Sources for (a) through (o) are UNL 2005; Moulton 1986, 1987, 1993.] **(a)** Richardson, 1804; **(b)** Nemaha, 1804; **(c)** Otoe, 1804; **(d)** Douglas, 1804; **(e)** Washington, 1804; **(f)** Burt, 1804; **(g)** Burt, 1804; **(h)** Dixon, 1804; **(i)** Dixon, 1804; **(j)** Dixon/Cedar, 1804; **(k)** Knox, 1804; **(l)** Knox, 1804; **(m)** Knox, 1806; **(n)** Knox/Cedar, 1806; **(o)** Washington, 1806; **(p)** Otoe, 1811 (Bradbury 1819); **(q)** Sarpy, 1811 (Bradbury 1819); **(r)** Burt, 1811 (Bradbury 1819); **(s)** Douglas, 1811 (Brackenridge 1814); **(t)** Knox, 1811 (Bradbury 1819); **(u)** Cuming, 1819 (James 1823); **(v)** Sarpy, 1820 (Fuller and Hafen 1957); **(w)** Keith, 1820 (Fuller and Hafen 1957); **(x)** Garden, 1834 (Townsend 1839); **(y)** Scotts Bluff, 1841 (Hafen and Hafen 1956); **(z)** Nance, 1844 (Carleton 1845); **(aa)** Lancaster, 1856 (Hanson 1996), **(bb)** Cherry, 1856 (Hanson 1996); **(cc)** Madison, 1871 (Swenk 1907); **(dd)** Antelope, 1871-72 (Cary 1905); **(ee)** Valley, 1872 (C.E. 1872), **(ff)** Thomas, 1873 (Schwatka 1888); **(gg)** Cheyenne, 1877 (NGPC 1995); **(hh)** Wheeler, 1877 (Cary 1905); **(ii)** Dawson, 1882 (Kinch 1998).

1839). Father Pierre-Jean DeSmet described the behavior of elk in response to drought on the South Fork of the Platte River in southwestern Nebraska: "All herbage is burnt up; the rivers and creeks are dry; the buffalo, elk and deer withdraw to distant spots, keep on the edge of the expiring vendure" (Chittenden and Richardson 1905). Rufus Sage reported that game was plentiful in western Nebraska in 1841 (Hafen and Hafen 1956). Members of various military expeditions observed elk and other game animals during their travels through Nebraska (Carleton 1845; Hanson 1996). Jones (1964) believed that elk were distributed throughout Nebraska but were more abundant in eastern than western Nebraska. They experienced less competition for food resources with bison and found better cover along the many rivers of eastern Nebraska.

Records of Elk on the Great Plains

Observations of elk were recorded throughout the Great Plains similar to those documented in Nebraska. Elk once ranged from northern New Mexico south to the border of Mexico but were extirpated from the state in the early 1900s (O'Gara and Dundas 2002). Findley et al. (1975) placed the extirpation of the southern elk "in New

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TABLE 1
DOCUMENTED OBSERVATIONS BY THE LEWIS AND CLARK EXPEDITION OF ELK IN NEBRASKA ALONG THE MISSOURI RIVER, 1804-6

Date of observation	Type of observation	Approximate location in Nebraska
July 14, 1804	2-3 elk; shot at, but did not kill	Richardson County
July 15, 1804	"Fresh sign" of elk	Nemaha County
July 19, 1804	Elk sign (at least tracks)	Otoe County
July 27, 1804	Elk sign	Douglas County
August 1, 1804	1 elk shot by Drewyer	Washington County
August 8, 1804	Collins shot elk; Clark shot at but failed to kill an elk	Burt County
August 9-10, 1804	1 elk and much sign observed	Burt County
August 23, 1804	1 elk killed; 2 elk observed swimming across the Missouri River	Dixon County
August 24, 1804	4 elk killed; wounded 2 elk	Dixon County
August 25, 1804	1 elk killed	Dixon–Cedar county line
September 2, 1804	1 elk killed	Knox County
September 5, 1804	2 elk killed	Knox County
September 1, 1806	1 elk killed	Knox County
September 3, 1806	Band of elk seen but it escaped	Knox or Cedar County
September 7, 1806	4 elk killed	Washington County

Source: Moulton 1986, 1987, 1993; UNL 2005.

Mexico about 1900 and the northern ones were essentially gone by 1909." Wyoming probably had the highest densities of elk in North America in historic times, and large numbers of elk persisted while the Great Plains was settled in the 1800s (Murie 1951). Elk were also common in all areas of Colorado, although the mountainous west gained the most attention in documentations of elk (Murie 1951). However, the number of elk dropped to between 500 and 1,000, restricted to the north-central mountains of the state by 1910 (Armstrong 1972). Large herds of elk inhabited most of Montana when explored by Lewis and Clark in 1805-6, but the population declined during the late 1800s, resulting in the complete extirpation in the eastern parts of the state by 1910-20 (Bryant and Maser 1982). Populations of elk in western Montana began increasing with the closure of hunting seasons in 1913. Elk were distributed throughout North Dakota before the arrival of settlers, after which they quickly became uncommon (Murie 1951). Elk occurred throughout South Dakota in presettlement times and were abundant in the early 1800s, especially in the Black Hills (Murie 1951). However, the last native elk in South Dakota was killed in 1888 (Higgins et al. 2000). In Kansas, elk were "common over most of the state" in the 1800s (Hoffmeister 1947), but by 1890 no elk were found in western Kansas (Choate 1987). Distributions of elk were described as "patchy" in Oklahoma (Murie 1951), and elk were almost eliminated from the state by the 1850s. However, Caire et al. (1989) reported an elk being shot in Kiowa County in southwestern Oklahoma in 1881. In historic times, elk in Texas were restricted to the Guadalupe Mountains, Culberson County, of the Trans-Pecos region of the state, but they were extirpated by 1900 (Genoways et al. 1979; Schmidly 2004). Elk probably ranged over the entire state of Missouri prior to arrival of Euro-Americans, but by 1830 they were already scarce. Large herds were reported in the southeastern and northwestern portions of the state, but they were gone by 1880 (Schwartz and Schwartz 1959). Murie (1951) reported that elk were abundant in the area of New Madrid area in extreme southeastern Missouri

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TABLE 2
OBSERVATIONS OF ELK IN NEBRASKA FOLLOWING THE LEWIS AND CLARK EXPEDITION

Observer	Date of observation	Type of observation	Approximate location in Nebraska	Source
John Bradbury	April 25, 1811	2 elk killed	Otoe County	Bradbury 1819
John Bradbury	April 29, 1811	"9 flocks of elk and deer"	Sarpy County	Bradbury 1819
John Bradbury	May 9, 1811	19 elk	Burt County	Bradbury 1819
Henry Brackenridge	May 12, 1811	"Several elk and deer"	Douglas County	Brackenridge 1814
John Bradbury	May 22, 1811	2 elk killed	Knox County	Bradbury 1819
Members of the Maj. Stephen Long expedition	December 15, 1819	"A few bisons, antelopes, and elks"	Elkhorn River, Cuming County	James 1823
Capt. J.R. Bell	June 6, 1820	Elk	Sarpy County	Fuller and Hafen 1957
Capt. J.R. Bell	June 27, 1820	Herd of elk	Keith County	Fuller and Hafen 1957
John Townsend	1834	"Large band of elk"	Platte River, central Nebraska	Townsend 1839
John Townsend	1834	"A few elk and antelopes"	Garden County	Townsend 1839
Fr. Pierre-Jean DeSmet	May 28, 1840	Buffalo, elk, and deer	South Fork Platte River	Chittenden and Richardson 1905
Rufus Sage	October 26, 1841	"Numerous bands of buffalo, elk, deer, sheep, and antelope"	Scotts Bluff County	Hafen and Hafen 1956
Lt. Carleton	September 1, 1844	"Large elk"	Beaver Creek, Nance County	Carleton 1845
Lt. G.K. Warren	1856	"Some elk"	Middle Creek, Lancaster County	Hanson 1996
Lt. G.K. Warren	1856	"Band of elk"	Niobrara River, Cherry County	Hanson 1996

in 1859. In Iowa, elk were most common in the western two-thirds of the state prior to settlement, although they were distributed throughout (Dinsmore 1994). Elk were typically observed in small groups in Iowa; large herds were rarely documented. Bowles (1971) reported the last large herd of elk in Iowa occurred along the Ocheyedan River valley, Osceola County, in the winter of 1871, and it "was driven south along the Little Sioux River, where the bulk of the herd was killed before reaching the Missouri River." Elk were located throughout Minnesota, although they were most numerous on the prairies and forests of the southern, western, and northern sections of the state until they were extirpated in 1908 (O'Gara and Dundas 2002).

Extirpation of Elk from Nebraska

Elk were hunted in Nebraska, as in other states of the Great Plains, as a secondary source of food by Native Americans, explorers, cavalry, and settlers when bison were not available (McCabe 1982). Aside from the immediate benefits as a food source, the most valuable parts of elk were the hide and upper canine teeth, or ivories, which were used for leather and adornment, respectively. The antlers were used to produce weaponry, saddles, implements, medicine, decorations, and various other products. An example of use of elk antlers by Native Americans in Nebraska comes from Cedar County in northeastern Nebraska, where an antler club or hammer and a polished elk

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antler point were recovered from excavation sites (Cooper and Bell 1936). The many uses of elk parts, specifically the prized upper canines, led to the targeted killing of elk, which "caused a marked decrease in the number of elk" (Adams 1982).

In 1849, Captain Howard Stansbury noted that hunting was poor along the Little Blue River valley because of "the game having been driven from the vicinity of the traveled route by the unintermitted stream of emigration which had already passed over the road" (Stansbury 1852). Subsistence hunting along the various emigrant routes, such as the Oregon, Mormon, and Deadwood trails, had a negative impact on populations of elk and other game species. Beyond need-based hunting, however, was the impact of the "slaughter every day, from the mere wantonness and love of killing, the greenhorns glorying in the sport, like our stripling of the city, in their annual murdering of robin and sparrows," noted by naturalist John Townsend as he journeyed along the Platte River in 1834 (Townsend 1839).

Elk were extirpated from Nebraska in the early 1880s about the same time as the plains bison (Swenk 1907) due to the consumptive use of elk by settlers, miners, market hunters, and others from 1850 to 1900. Other possible causes for decline in wildlife in the Great Plains included the idea of "manifest destiny," the discovery of gold in the Black Hills of South Dakota, no laws or regulations relating to wildlife conservation, and the government's agenda with Native American tribes. "Westward expansion, more efficient rifles, transcontinental railroads that provided access and a means of hauling animal parts and a booming market for meat, furs, hides and ivories resulted in bison, elk, deer, pronghorn and other wildlife being rapidly reduced in numbers" (Stalling et al. 2002). Market hunting for bison is well documented, but this is not the case for elk, although some anecdotal stories indicate that elk were taken and commercially traded in Nebraska. John MacMurphy, who in 1857 was engaged in the mercantile business in Decatur in present-day Burt County, NE, stated, "A large part of the business was in furs, robes and skins. We got a great many buffalo robes, yet, beaver, mink, otter, fox and now and then a bear skin or a silver gray fox. Antelope, deer and elk skins were plenty" (MacMurphy 1894). He also noted the interaction between humans and environmental condition in the decline of wildlife: "The bones of elk, antelope, deer and buffalo were numerous on the prairie. It seems to me as if every forty acres must have had at least one skeleton or a portion of the remains of one of these animals. The heavy snow of the winter of 1856-7 wore the small game out, or they starved, and the Indians and what white hunters there were, caught them in drifts and cut their throats by the thousands for their skins."

Game populations in Nebraska may have been impacted earlier than elsewhere in the Great Plains because early exploration of the region followed the Missouri River along the eastern boundary of the state and some of the earliest emigrant routes such as the Oregon and Mormon trails followed the Platte and North Platte rivers through the state. Finally, the first transcontinental railroad was the Union Pacific, which followed much the same route as the emigrant trails. Easy access provided by the railroads sped the trade for bison and undoubtedly for other large game species from the early 1870s until populations were eliminated in the early 1880s. It was along the route of the emigrant trails and Union Pacific railroad that the Great Plains herd of bison was split into the northern and southern herds and then systematically eliminated. The railroad created demand for fresh meat during construction and provided easy transportation of goods to the east, including hides. The railroad also provided access and promoted sport hunting along its route (Hanner 1981) such as the well-documented hunt lead by William F. "Buffalo Bill" Cody out of North Platte in 1872 for Grand Duke Alexis of Russia (McHugh 1972). Although bison were the primary targets of these hunts, other local game species were taken and elk with magnificent antlers were tempting targets.

The railroad also sped the settlement of Nebraska: by 1880 the human population of the state was approaching 500,000 and over 70 of the current 93 counties had been established. Movement of public domain into private hands and development of farming and ranching caused a loss of habitat for game species and increased conflicts between humans and wildlife, resulting in the death of many game animals. Current conflicts between elk in agricultural areas include damage to field crops, stored hay, fences, and competition with livestock for forage.

Public sentiment for wildlife protection grew as populations of wildlife declined in the late 1800s. Federal restrictions on taking wildlife began in earnest with the Lacey Act of 1900, which made the interstate transportation and sale of wildlife illegally taken under state law a federal offense. The Lacey Act supported enforcement of state wildlife laws and was the first major piece of federal wildlife legislation (Musgrave 1998). It was not until 1907, however, that the Nebraska Legislature enacted laws that prohibited anyone to "pursue, take, wound, or kill any elk, deer, antelope, or beaver" (NGPC 1995). However, as stated in an early article on the conservation

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TABLE 3
OBSERVATIONS OF ELK PRIOR TO EXTIRPATION IN NEBRASKA

Observer	Date of observation	Type of observation	Approximate location in Nebraska	Source
M. Swenk	1871	1 elk killed	Madison County	Swenk 1907
Unknown	1871-72	Several elk killed	Antelope County	Cary 1905
U.S. Cavalry	October 1872	9 elk harvested	Between the North and South Loup rivers, Valley County	C.E. 1872
F. Schwatka	Fall 1873	19 elk killed	Between the Middle Loup and Dismal rivers, Thomas County	Schwatka 1888
Unknown	January 1877	60 elk	Cheyenne County	NGPC 1995
Unknown	December 1877	84 elk	Wheeler County	Cary 1905
Early settler	Spring 1882	1 bull elk	Dawson County	Kinch 1998

of Nebraska game resources, "the continued presence of the vast herds of large game mammals was incompatible with the settlement of our state and the development of its agricultural resources" (Wolcott and Shoemaker 1918). It is not surprising that public sentiment was slow to react to the loss of these natural resources.

Final Documentation of Elk Prior to Extirpation in Nebraska

Later explores, settlers, and members of military expeditions documented observations of elk in Nebraska. Swenk (1907) noted one elk killed in Madison County in 1871 and several killed near the head of Braner Creek (Cary 1905) in northeast Nebraska (Table 3). Elk were last seen in Madison County in 1875 and probably disappeared from Antelope County in northeastern Nebraska about the same time (Cary 1905; Fig. 2). Members of the U.S. cavalry harvested nine elk in 1872 in central Nebraska (C.E. 1872). Schwatka led members of a military hunting expedition in 1873 that killed 19 elk in north-central Nebraska, and reported that the size of the herd was "six to eight hundred, if not a thousand strong" (Schwatka 1888). A herd of 60 elk was observed in western Nebraska in January 1877 (NGPC 1995). The final sighting of a large herd of elk in Nebraska was reported in Wheeler County in central Nebraska in 1877 (Cary 1905). A male elk was observed in northeast Nebraska in 1882 (Kinch 1998). Swenk (1907) believed that "elk disappeared from the state contemporaneously with the final extinction of the plains bison, in the early [18] eighties." Wolcott and Shoemaker (1918) also placed the disappearance of the elk from Nebraska in the early 1880s.

Return of Elk to Nebraska

Intermittent sightings of elk, both individuals and small herds, were reported in the 1950s and 1960s in western Nebraska (NGPC 1995). Gunderson (1976) reported that the first recent sighting of elk was in Box Butte County in western Nebraska in 1958, and a female and calf elk were seen in Garden County in 1964. Forty-three elk (22 males, 11 females, 10 calves) were translocated from Yellowstone National Park to the Rawhide Buttes, Goshen County, in eastern Wyoming in 1967-68. Some of these elk moved eastward to the Pine Ridge region of Nebraska. One collared spike-antlered male released in the Rawhide Buttes, Wyoming, in February 1967 was found 15 km north of Hay Springs in Sheridan County in northwestern Nebraska in August 1967. The elk traveled at least 115 km from its release site in Wyoming. A second collared elk, a 9-year-old male, was released in the Rawhide Buttes in January 1968 and its skeleton was recovered south of Harrison in Sioux County in northwestern Nebraska in September 1969 (Stillings 1999). By the early 1970s, a herd of elk had become established in the Bordeaux Creek drainage near Chadron in Dawes County in northwestern Nebraska (NGPC 1995).

The herd that formed in the Bordeaux Creek in the early 1970s grew to a population of approximately 75 elk by 1985, which was beyond what some landowners were willing to tolerate. In 1986 and 1987, 117 elk permits were

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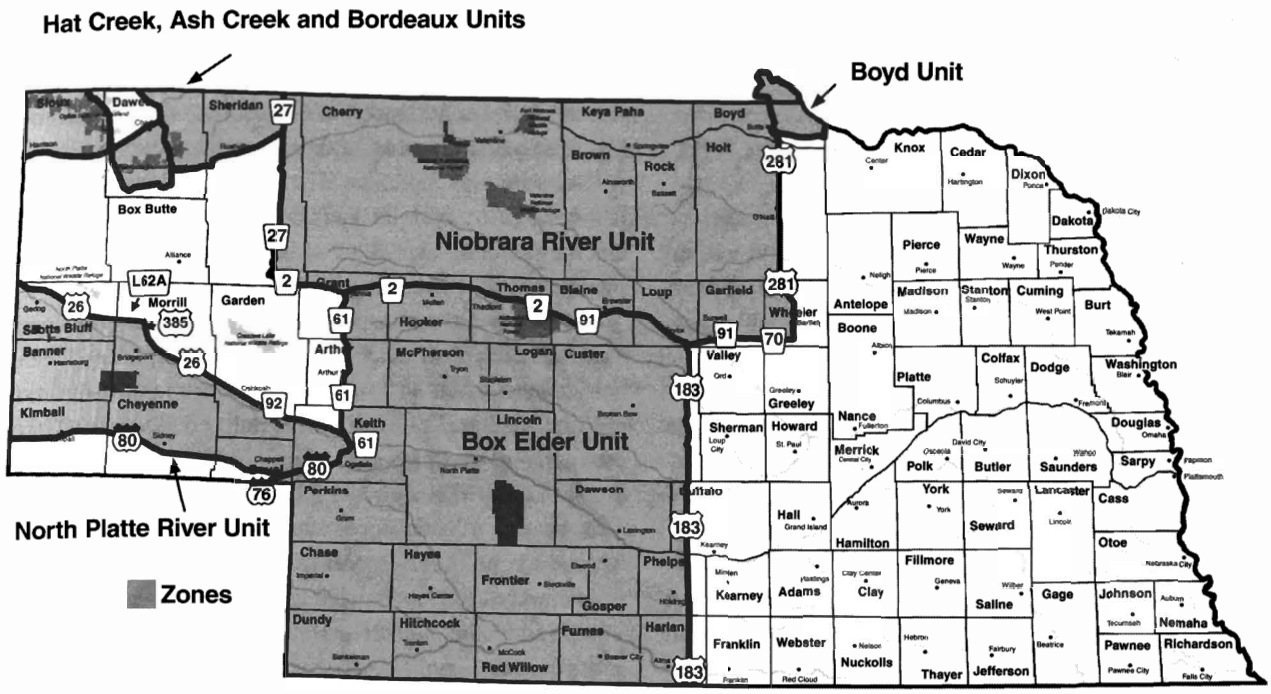

Figure 4. Nebraska elk management units (EMUs) in 2008.

issued, resulting in the harvest of 30 animals and reduced landowner complaints. By 1997, 150 elk occupied the Hat and Bordeaux Creek areas in the Pine Ridge and landowner tolerance had increased (Crank 1998; Cover 2000). Annual hunting seasons for elk were initiated in the Hat and Bordeaux Creek Elk Management Units (EMUs, Fig. 4) in the fall of 1995 and continue to the present. Since 1995, 323 elk have been harvested in the two EMUs, including 127 males, 179 females, and 17 calves. Landowners who adamantly opposed elk in the Pine Ridge in 1985 became more accepting of elk, and during public meetings in 2004 asked NGPC to allow populations to increase in other areas of the Pine Ridge. Elk expanded their range to include the Ash Creek area in 2000 (Fig 4). Since 2004, 22 elk have been harvested in the Ash Creek EMU, including 12 males and 10 females.

In addition to the Pine Ridge, elk recolonized four other areas across Nebraska after the late 1980s. A migratory herd of elk became established in Boyd County in northeastern Nebraska (Fig. 4) and southern South Dakota in the late 1980s. The elk overwinter in South Dakota, migrate across the state boundary in spring, and spend the summer and fall in Nebraska before returning to South Dakota. Annual hunting seasons were initiated in the Boyd EMU in fall 1996 and continue to the present. A permit for the Boyd EMU allows hunting in Boyd County, NE, and Gregory County, SD (NGPC 2007). Since 1996, 40 elk have been harvested in the Boyd EMU, including 14 males, 23 females, and 3 calves. Elk were first observed in the loess canyons southeast of North Platte, Lincoln County, NE, in the mid-1980s as eastern redcedar (*Juniperus virginiana*) became established in the area (Hoffman 2005). The area is now the Box Elder EMU (Fig. 4) and is home to about 40 elk. Elk herds are now found along the entire North Platte River from the Wyoming border to Lake McConaughy and along the Niobrara River in Cherry and Sheridan counties. At least two elk were observed in the vicinity of Lincoln, Lancaster County, in southeastern Nebraska in recent years. One male elk was hit and killed by a car near the junction of Interstate 80 and U.S. Highway 77 just west of Lincoln in October 2003 (Hicks 2004). Another was observed along Salt Creek in northwest Lincoln on October 2, 2006 (Laukaitis and Duggan 2006). These and other sightings outside areas known to be occupied by herds of elk indicate that elk continue to reclaim more of their former geographic range in Nebraska.

By the spring of 2004, the population of elk in Nebraska was estimated at 670, with 420 elk in the Pine Ridge. The population estimate of summer 2007 was 900 in the Pine Ridge, 150 in the North Platte River EMU, 100 in the Niobrara River EMU, 75 in the Boyd EMU, and 100 in the

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Box Elder EMU. The total number of elk harvested in the state since 1986 has been 456 individuals (176 males, 229 females, 21 calves, and 30 unknown).

Return of Elk to the Great Plains

Based on recent reports from big game biologists from all states in the Great Plains, free-ranging elk are currently found in Colorado, Kansas, Minnesota, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, and Wyoming, but they are not currently present in Iowa or Missouri. We concentrated on population estimates of elk according to the Great Plains boundaries. The Colorado Division of Wildlife reported that 9,000 to 10,000 elk occupy five management units on the eastern plains and foothills areas (T. Verquer, pers. comm. 2008). Kansas reported 175 to 200 elk concentrated in two herds (M. Peek, pers. comm. 2008). Minnesota reported two herds of elk, totaling about 100 individuals, found in the northwestern part of the state (J. Huener, pers. comm. 2008). One of these herds regularly crosses the border into Manitoba, Canada. The eastern three-quarters of Montana are occupied by 16,000 to 17,000 elk (K. Hamlin, pers. comm. 2008). Nebraska estimated a population of 1,400 elk in seven EMUs throughout the western two-thirds of the state (K. Hams, pers. comm. 2007). New Mexico reported 3,000 to 5,000 elk distributed among three distinct herds in the eastern half of the state (S. Liley, pers. comm. 2008). North Dakota estimated that 1,200 to 1,300 elk occupy the western portions of the state (B. Jensen, pers. comm. 2008). Oklahoma reported a population of 1,100 elk (M. Shaw, pers. comm. 2008). South Dakota reported 3,500 to 4,500 elk occupy the western and southern portions the state (T. Benzon, pers. comm. 2008). Texas reported approximately 75 elk in one herd located in the Panhandle region (B. Tarrant, pers. comm. 2008). In Wyoming, the population is estimated at 8,000 elk in nine herds east of the Rocky Mountains (R. Rothwell and R. Schilowsky, pers. comm. 2008). We estimate that 44,000 to 49,000 elk currently occupy the Great Plains.

Case Study: Elk in the Pine Ridge Area of Nebraska, 1995 to 1997

No studies of elk had been conducted in Nebraska prior to this report. Therefore, little was known about the demographics, distribution, movements, or habitat selection of elk in Nebraska. We observed two distinct herds of elk in the Pine Ridge of northwestern Nebraska (Stillings 1999; Cover 2000). Although seasonal shifts in home ranges occurred, no immigration or emigration was observed between the two herds. The Hat Creek herd was located 20 km northwest of Crawford and had an average annual home range of 44,035 ha and an average seasonal home range of 2,482 ha. The Bordeaux Creek herd was located 10 km east of Chadron and had an average annual home range of 48,398 ha and an average seasonal home range of 3,274 ha.

Fidelity to winter use areas was observed, as elk shifted their use areas from fall breeding areas located on upland tables to lower-elevation winter wheat fields. Winter use areas of elk in the Hat and Bordeaux Creek areas consisted of ponderosa pine forest (53%), pasture/grasslands (37%), and cropland (10%). Elk in the Hat Creek area selected three separate wintering areas compared to one in the Bordeaux Creek area. All winter use areas were located on privately owned land and averaged 3,943 and 3,002 ha for the Hat and Bordeaux Creek herds, respectively.

Elk in the Hat Creek area shifted spring use areas southward, but still overlapped their winter use areas. Spring use areas in the Bordeaux Creek overlapped winter use areas and shifted eastward, where higher percentages of forested habitat were available. Spring use areas in the Hat and Bordeaux Creek areas consisted of ponderosa pine forest (72%), pasture/grasslands (29%), and cropland (2%) and provided forested habitat in undisturbed canyons with early spring forage. The average size of spring use areas was 3,396 and 4,108 ha for the Hat and Bordeaux Creek herds, respectively.

Nearly all calving areas in the Hat and Bordeaux Creek study areas were located in small patches of ponderosa pine habitat. Elk calving grounds overlapped existing spring use areas. Calving areas in the Hat and Bordeaux Creek EMUs consisted of ponderosa pine forest (90%), pasture/grasslands (9%), and cropland (1%). Eighty percent of the calving areas ($n = 22$) were located on privately owned land. The average size of the calving areas was 1,042 and 1,784 ha for the Hat and Bordeaux Creek herds, respectively.

Summer use areas of elk in the Hat Creek EMU were in three distinct areas: the Hat Creek and Cottonwood Creek drainage that had served as past winter, spring, and calving range and two areas to the north of the Soldier Creek Wilderness Area. Summer use areas of elk in the Bordeaux Creek EMU shifted south to upland tables, and provided forested cover and proximity to alfalfa and oat fields. Summer use areas consisted of ponderosa pine forest (77%), pasture/grasslands (8%), and cropland (15%).

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The average size of summer use areas was 1,801 and 4,111 ha for the Hat and Bordeaux Creek herds, respectively.

Breeding areas in the Hat and Bordeaux Creek areas overlapped summer use areas. Upland tables provided forested canyons interspersed with fields of alfalfa, oats, and grassland pastures that provided forage and close hiding cover. Breeding habitat consisted of ponderosa pine forest (68%), pasture/grasslands (18%), and cropland (14%). The average size of breeding areas was 1,976 and 4,111 ha for the Hat and Bordeaux Creek herds, respectively.

Elk may compete more with cattle for forage than other big game species, because of similar diets (Nelson 1982). The distribution of elk in the Pine Ridge during the summers of 1995-97 was influenced by the presence of field crops (alfalfa, oats, and millet), suggesting that elk shifted foraging activity according to the location and phenological stage of crops and range grasses, and to avoid cattle. Mackie (1970), Rice (1988), and Cover (2000) all found elk preferred areas that received little or no prior use by cattle or vacated pastures in the presence of cattle. Elk play a subordinated role to cattle, and space competition results in elk movements.

Future of Elk in Nebraska

Potential habitat for elk in Nebraska is extensive and landowner tolerance for elk has increased (Crank 1998). Social tolerance for elk and the availability of unoccupied habitat will result in additional expansion of elk herds in most EMUs. We expect the social carrying capacity for elk is double or triple the current population level in the Pine Ridge, North Platte River, Box Elder, and Niobrara River EMUs. Most herds are expected to double in the next five years as annual population growth is likely 15% to 20% with the current limited harvest of female elk. As social tolerance for elk is met, harvest will need to be adjusted to stop herd growth or to reduce populations as necessary. A maximum herd size of 2,500 to 3,500 may be possible. If elk occupy the 52,000 km^2 of the Nebraska Sandhills region and landowners accept them, the upper limit for future populations of elk are likely to exceed 10,000 individuals. Fewer complaints associated with elk and higher acceptance of elk usually occurs in areas with lower densities of humans (Vermeire et al. 2004). Current EMUs will likely be expanded to allow for management options where elk occupy areas of unsuitable habitat or where landowners are intolerant of them.

Elk occupied privately owned land in the Pine Ridge almost exclusively during the calving and wintering periods in 1995-97. Management agencies should continue to work with landowners to protect these areas and to ensure that crop damage and other human–wildlife conflicts are maintained at or below tolerable levels. The NGPC is directed to respond to all complaints by landowners (NGPC 1995) and typically provides materials and technical assistance to alleviate crop damage caused by elk.

Our research on past and present distributions of elk provides insight into recolonization of former ranges and revealed causes of change in the distribution of elk in the Great Plains. The distribution and number of elk in the Great Plains will likely increase due to the availability of suitable habitat and highly regulated hunting of elk in the region. A balance between herd size and human tolerance must be attained for elk to continue to flourish. Proper management will allow elk to continue to be an important part of the fauna of Nebraska and the Great Plains in the future.

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