Movements and distribution of some northern Yellowstone elk
by John Michael Vore

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University

Abstract:
A study using radiotelemetered elk was conducted on the northern Yellowstone winter range to determine the movements and distribution of elk that winter outside Yellowstone National Park (YNP). Three herd segments were recognized. Elk that wintered outside YNP but summered within it moved as far as 151 km between winter and summer range. Hunting from early December to mid February was the major determinant of elk distribution and was shown to inhibit movements of some elk leaving YNP. Significantly (Chi square test, $p<.001$), 75% of 10,822 elk observed during 6 censuses were found on the 44% of winter range with limited public access. Telemetered elk were found in areas open to the public during 21.7% of 6,080 elk-days. Twelve telemetered elk captured and wintering near the hunting/no-hunting boundary were followed for 21 elk-winters. Of 15 elk-winters during the hunting season, 6 elk did not move into areas open to hunting. Of 9 elk moving into areas open to hunting 5 were killed, 3 returned to no-hunting areas, and one remained until spring migration. Following the hunting season, 6 elk moved into areas that had been previously open to hunting. During March 1989, the number of winter-killed elk carcasses on a transect at the Hunting/No-hunting boundary were nearly twice those found on 9 other transects along an elk migration route out of YNP. This reflected elk concentrations at the Hunting/No-hunting boundary.

After the hunting season, it is speculated that human activity on the northern winter range in the early spring perpetuates the elk distribution patterns established during the hunting season but does not cause elk to leave winter range early. Other findings related to elk diet composition, pregnancy rates, and dates of fetal conception are presented.

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APPROVAL

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John Michael Vore

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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Signature John M. Vore

Date 01.23.90

DEDICATION

To the memory of Arnie Foss, a damn good wildlife manager.

VITA

John Michael Vore was born in Fergus Falls, Minnesota, on January 5, 1956, the second of four sons to David H. and Helen E. Vore. He graduated from Roosevelt Senior High School in Fergus Falls in June 1974. At Bemidji State University in Bemidji, Minnesota he majored in music from 1974 to 1976. From 1980 to 1984 he attended Montana State University, receiving a B.S. in Biology in December 1984. He began his graduate studies in Fish and Wildlife Management at the same institution in January 1984. John married Denise Lynn Wilson on August 27, 1988.

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TABLE OF CONTENTS

TABLE OF CONTENTS -- Continued

TABLE OF CONTENTS -- Continued

LIST OF TABLES

LIST OF TABLES -- Continued

LIST OF TABLES -- Continued

LIST OF FIGURES

LIST OF FIGURES -- Continued

LIST OF FIGURES -- Continued

ABSTRACT

A study using radiotelemetered elk was conducted on the northern Yellowstone winter range to determine the movements and distribution of elk that winter outside Yellowstone National Park (YNP). Three herd segments were recognized. Elk that wintered outside YNP but summered within it moved as far as 151 km between winter and summer range. Hunting from early December to mid February was the major determinant of elk distribution and was shown to inhibit movements of some elk leaving YNP. Significantly (Chi square test, $p<.001$), 75% of 10,822 elk observed during 6 censuses were found on the 44% of winter range with limited public access. Telemetered elk were found in areas open to the public during 21.7% of 6,080 elk-days. Twelve telemetered elk captured and wintering near the hunting/no-hunting boundary were followed for 21 elk-winters. Of 15 elk-winters during the hunting season, 6 elk did not move into areas open to hunting. Of 9 elk moving into areas open to hunting 5 were killed, 3 returned to no-hunting areas, and one remained until spring migration. Following the hunting season, 6 elk moved into areas that had been previously open to hunting. During March 1989, the number of winter-killed elk carcasses on a transect at the Hunting/No-hunting boundary were nearly twice those found on 9 other transects along an elk migration route out of YNP. This reflected elk concentrations at the Hunting/No-hunting boundary.

After the hunting season, it is speculated that human activity on the northern winter range in the early spring perpetuates the elk distribution patterns established during the hunting season but does not cause elk to leave winter range early. Other findings related to elk diet composition, pregnancy rates, and dates of fetal conception are presented.

INTRODUCTION

The northern Yellowstone elk herd is one of the largest in the world. Because these elk are central to much of the high-profile controversy about resource management in the Yellowstone area (Erickson 1981, Tyers 1981, Chase 1986, Despain et al. 1986, Mahlein 1987), the herd is one of the most well known. Most elk summer in Yellowstone National Park (YNP); in winter some migrate into Montana (Houston 1982, Swenson in prep., this study).

Montana's general elk hunting season runs from the last week in October to the end of November. On the northern range an additional season involving elk moving out of the Park, known as the "Gardiner late hunt", lasts from early December to mid- or late-February. These elk are an important game resource in Montana. In some years the late hunt harvest constitutes 10 percent of the state-wide elk harvest (Singer and Lehmke 1989). Erickson (1981) and Houston (1982) have summarized the history of the Gardiner late hunt.

Gathering cast antlers of elk to sell has become a popular activity in the last 15 years (McCafferty 1983). Most antlers eventually are shipped to Asia. Antlers are sold to Montana dealers at $11.00 to $18.00 per kg.

People generally hunt for antlers in the spring when elk are still concentrated on winter range and are in poor condition. Elk managers have been concerned about harassment of elk by antler hunters.

Although many studies have documented movements and distribution of northern Yellowstone elk (Skinner 1925, Rush 1932, Kittams 1963, Ellis 1965, Craighead et al. 1972, Shoesmith 1979, Houston 1982), none have focused on elk that winter outside the Park. Objectives of this study were: 1) to document movements and distribution of northern Yellowstone elk that winter outside YNP, and 2) to investigate the effects of recreation, specifically hunting and antler hunting, on elk distribution and movements. Secondary objectives include: description of elk winter diet composition, pregnancy rates, *in utero* sex ratios, and the distribution of winter-killed elk.

Field work was conducted from January 1984 to May 1987 with the most intensive work during November to May of each year. A count of winter-killed elk was conducted in March 1989.

STUDY AREA

Location, Size, and Ownership

The study area included the seasonal ranges used by the northern Yellowstone elk herd in northwest Wyoming and southcentral Montana as described by Houston (1982) and Erickson (1981)(Fig. 1). Summer range includes most of the eastern two-thirds of the Yellowstone National Park (YNP) and adjacent lands up to 26 km north of the Park boundary.

The >100,000 ha winter range lies along the Lamar and Yellowstone Rivers. It stretches for >80 km from its southeast end along Soda Butte Creek to Sixmile Creek, 26 km north of the Park. Cole (1969) divided the winter range into "upper" and "lower" portions (Fig. 2). Houston (1982) identified the portion within the Park and adjacent to the boundary as the Boundary Line Area (BLA) (Fig. 2). Mammmoth, Wyoming and Gardiner, Montana are in the heart of the winter range. About 20% of the entire winter range is outside the Park.

Most land used by the northern Yellowstone elk is in public ownership (U.S. Park Service, U.S. Forest Service, State of Montana). However, roughly one-third of winter range outside the Park (10% of the entire winter range) is

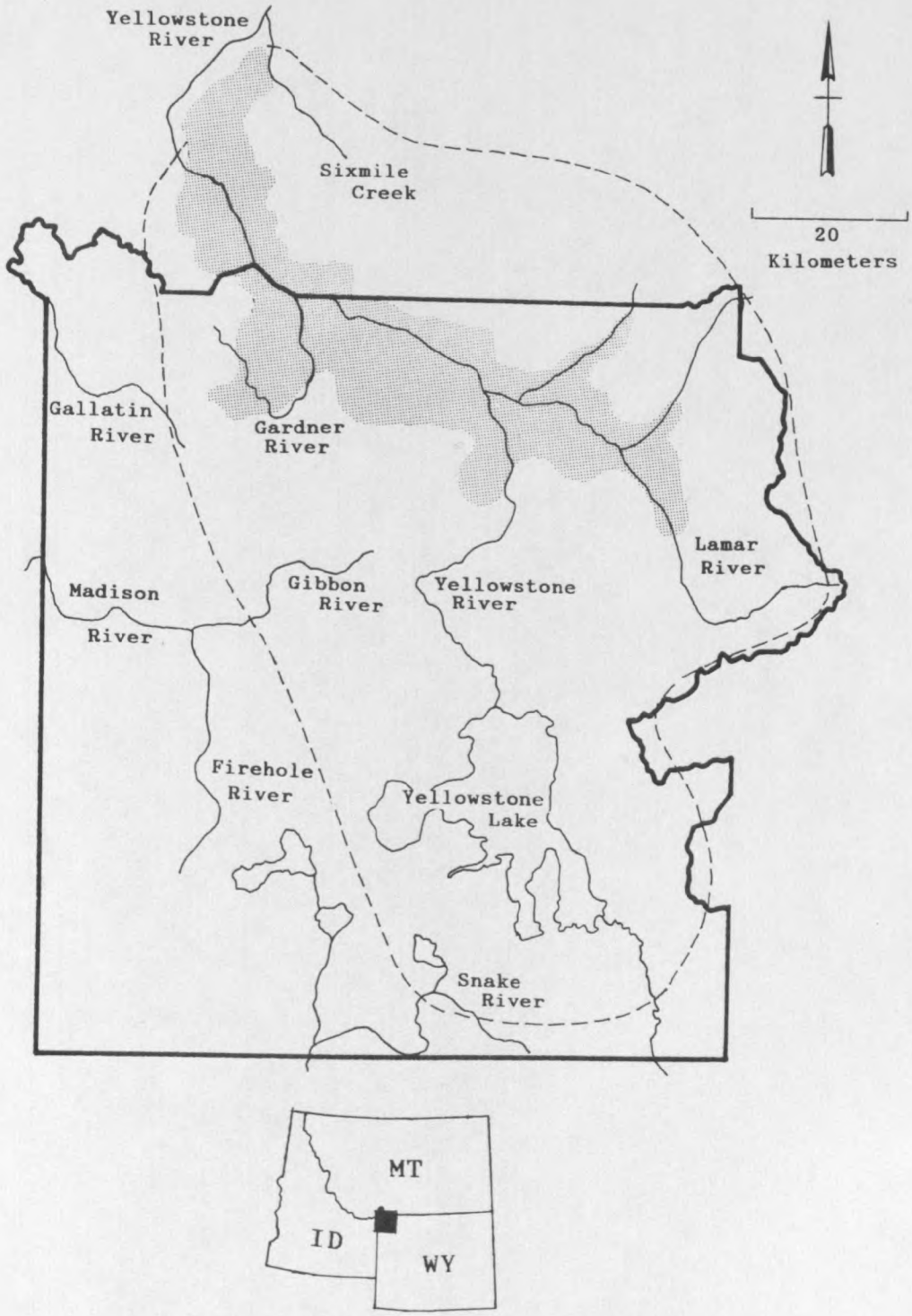

Figure 1. Map of study area showing summer range boundary (dashed line) and winter range (shaded area) of the northern Yellowstone elk.

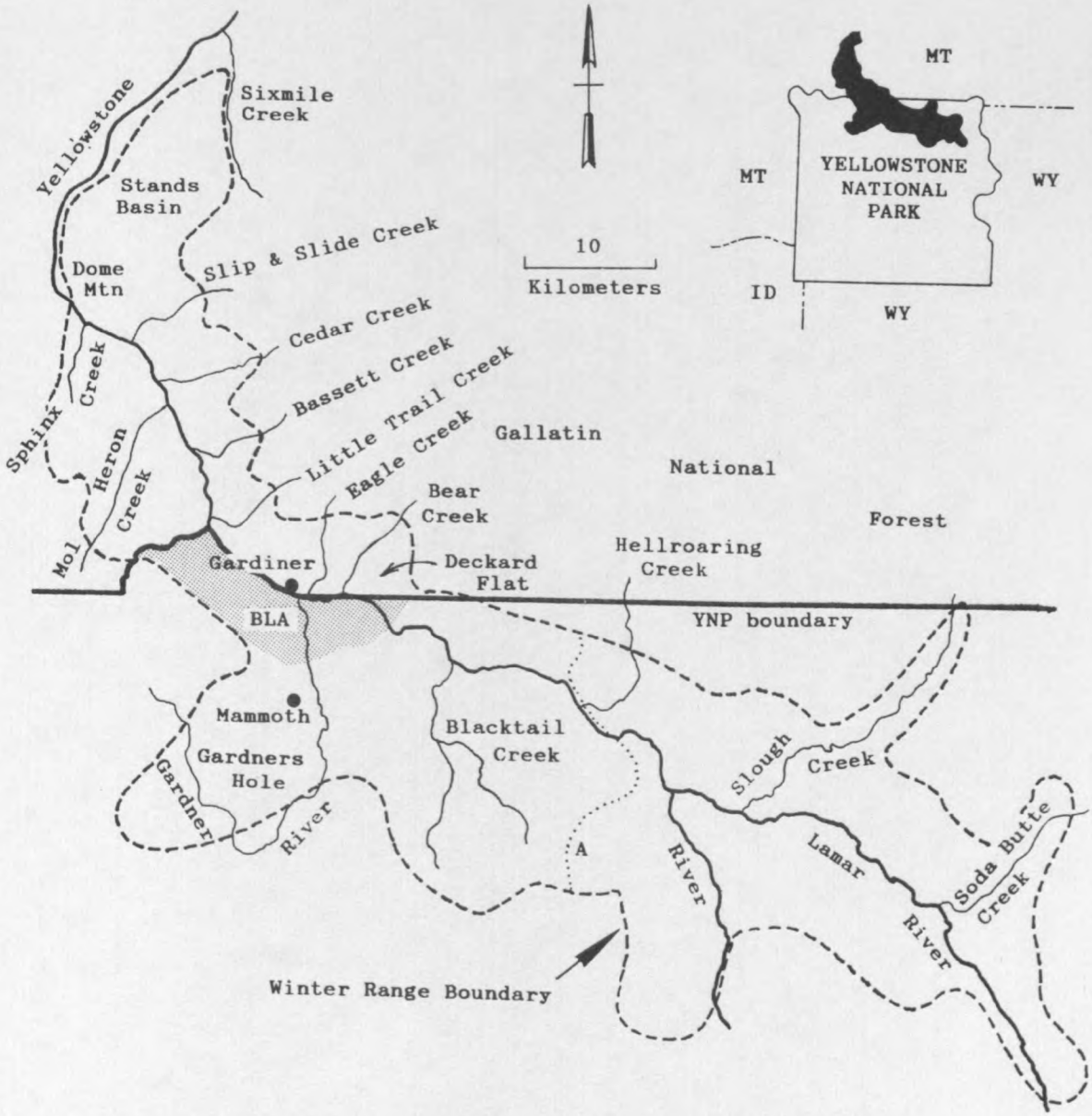

Figure 2. Map of the northern winter range. BLA is the boundary line area and A divides the upper and lower ranges according to Cole (1969).

privately owned. This percentage was lessened in 1986 when 1200 ha was purchased by the State of Montana.

Physiography and Climate

Elk summer range in the Park's interior is a high volcanic plateau largely surrounded by mountains. The plateau is bordered on the east and north by the Absaroka Range, the west by the Gallatin Range, and the south by the Teton Range. The average elevation in the Park is about 2440 m. Mountains within the summer range exceed 3049 m. Lower elevations in valleys range from 1524 to 2134 m. Most elk summer in areas from 2000 m to above 2900 m.

Dirks (1982) summarized the climate of Yellowstone Park; all temperature and precipitation data presented here are his unless otherwise noted. Climatological data on elk summer range is poorly represented because recording stations are at lower elevations.

Summers on elk range in the Yellowstone area are short and cool with frost or snow expected during any month. In the Lamar Valley (Elev. 1973 m), average June, July, and August temperatures are 10.7, 14.2, and 13.2 °C, respectively. The average number of frost free days (>0°C) at Mammoth (Elev. 1902 m) is 91. At typical elk summer range elevations these averages would be lower.

Winters on the northern winter range are long and cold. At Mammoth, the coldest months (December and

January), average -5.9 and -7.1 °C, respectively. Winter usually lasts from November to April, but can stretch from October through May.

Although snow often restricts elk to elevations below 2200 m, higher windswept ridges are used by elk. South to southwest aspects are also important wintering sites. The lowest elevation on the study area was 1524 m at the northern end of the winter range, outside the Park. Elk here were usually excluded from the valley floor because of conflicts with humans.

Some areas of YNP average as much as 203 cm of precipitation annually, however most elk summer range receives 76-127 cm. Most of the winter range averages 50-76 cm a year, but a rain shadow along the Yellowstone river below 1555 m (downstream from Gardiner) averages less than 30 cm (Farnes 1975). Most precipitation falls as snow.

Wind is an important factor on the lower winter range, especially north of Dome Mountain. In the Stand's Basin area, wind velocities often exceed 64 kph for days at a time. In open areas, this removes snow and exposes forage.

The basic geology of the area is volcanic, though large portions have been subject to glaciation (McNeil 1984, Houston 1982). Much of elk summer range is underlain by Tertiary andesetic bedrock of the Absaroka

volcanism (Despain 1973). Soils tend to be shallow and poorly developed (Meagher 1973).

Most of the elk winter range lies over Quaternary sediment and granite bedrock (Despain 1973). Glaciation, either through deposition or scouring, has played a major role in soil formation (Despain 1973). Mollisols, inceptisols, and alfisols make up most of the areas soils (Montagne 1982).

Flora and Fauna

Vegetation of the study area has been described by Houston (1982). Elk summer range is mostly in the spruce-fir zone (Despain 1973) and is predominately forested. Lodgepole pine (*Pinus contorta*) is the most abundant tree species over most of the area, but Douglas fir (*Pseudotsuga menziesii*), subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmanii*), whitebark pine (*Pinus albicaulis*), and aspen (*Populus tremuloides*) are common in some areas.

Winter range is in the Douglas fir zone (Despain 1973). Dominant tree species include lodgepole pine and Douglas fir, but stands of aspen, spruce and subalpine fir are also found. In the rain shadow area north of Gardiner, limber pine (*Pinus flexilus*) and Rocky Mountain juniper (*Juniperus scopulorum*) are well represented.

The northern winter range is an open sagebrush/grassland steppe with trees found on mesic sites and north-facing slopes. Big sagebrush (*Artemisia tridentata*) is the dominant shrub, but rabbitbrush (*Chrysothamnus* spp.) is common. Willow (*Salix* spp.), where they are protected from browsing, and alder (*Alnus* spp.) can be found on mesic sites and along creeks. In xeric areas around Gardiner, greasewood (*Sarcobatus vermiculatus*) and saltbrush (*Atriplex* spp.) are abundant. Major grasses are Idaho fescue (*Festuca idahoensis*) and bluebunch wheatgrass (*Agropyron spicatum*). Junegrass (*Koleria cristatum*), giant wild rye (*Elymus cinerus*), needle-and-thread (*Stipa comata*), and Indian ricegrass (*Oryzopsis hymenoides*) are present on drier sites.

Ungulates that share the region with elk are: bison (*Bison bison*), moose (*Alces alces*), bighorn sheep (*Ovis canadensis*), mule deer (*Odocoileus hemionus*), and pronghorn antelope (*Antilocapra americana*). Carnivores on the study area include: grizzly bear (*Ursus arctos*), black bear (*U. americanus*), coyote (*Canis latrans*), and mountain lion (*Felis concolor*).

METHODS

Elk Capture, Radiotelemetry, and Censuses

In 1984 elk were darted from a helicopter using succinylcholine chloride. In 1985-86 elk were caught in Clover traps (McCullough 1975). Animals were aged by dentition according to Quimby and Gaab (1957) and Greer and Yeager (1967), fitted with individually recognizable polyvinyl chloride (PVC) radio collars (Pederson 1977), and most were fitted with numbered aluminum ear tags.

Aerial relocations of marked elk were made in a Piper Super Cub using a directional, belly-mounted Yagi antenna. Flights were usually made monthly in summer (mid-June through November) and twice monthly in winter. Ground relocations were done by triangulation using a hand-held Yagi antenna. Relocations were plotted on 1:62,000 USGS topographic maps using Universal Transverse Mercator (UTM) coordinates. Aerial relocations were assumed to be accurate to within a 5.5 ha circle (Denton 1973). Ground relocations without visual confirmation were less accurate but the drainage where elk were located was accurately determined. The Telday computer program (Montana Department of Fish, Wildlife and Parks 1985) was used in analyzing relocation data. This program determined the size of a convex polygon home range and used the methods

of Hayne (1949) in determining the geographic activity center (GAC, an "average" point among the relocations) and Harrison (1958) for the standard diameter (SD) of relocations. The standard diameter includes 68% of relocations and is less sensitive to differences in the number of relocations than is the convex polygon. Observations of well-used trails and elk tracks were helpful in determining movement routes, as was the informed input of area residents. Elk censuses were done from an airplane by recording locations and group sizes of elk on a 1:62,000 USGS topographic map.

Seasonal Ranges and Movements of Marked Elk

Three herd segments, "Migratory", "Resident", and "West River", were recognized (Craighead et al. 1972, Houston 1982). Migratory and Resident animals had seasonal ranges east of the Yellowstone River. Migratory elk wintered outside but summered mostly within YNP. Resident elk never entered the Park. West River elk had summer ranges in the vicinity of Gardners Hole and wintered in the BLA (Fig. 2).

Six seasonal ranges were defined similar to Cada (1978): terminal winter, early spring, calving, summer, rut, and early winter. Terminal winter and summer ranges were defined by seasonal use areas with the greatest distance between them. Calving and rut ranges were

defined by relocations obtained from mid-May to mid-June and September-October respectively, but included relocations when the animal arrived earlier and/or stayed later. Early winter and early spring were transitional ranges occupied preceeding and following use of terminal winter range. In effect these latter 2 broke winter range use into 3 periods. Only relocations obtained when an animal was found on a seasonal range were used in determining range size. Seasonal movement distances were estimated by the straight-line distance between seasonal range GACs. It was assumed that days between locations were equally distributed along the distance between them.

Late Hunt and Spring Distribution and Movements

Areas open to the public (public land and some private land) were compared with ones that had limited public access (actively restricted private or inaccessible public land) to determine the effects of hunting and spring recreation (including antler hunting) on elk distribution and movements. Elk distribution on winter range outside YNP was analyzed temporally and spacially for each year and for all years combined. Two time periods: "Hunt" and "Spring", and 2 classifications of land access by the public: "Access" and "No-Access" were used. The Hunt period was during the late hunt. The Spring period included dates following the Hunt period to May 15. By this date most migratory elk had moved into the Park.

Spatially, winter range outside YNP was divided into 12 "blocks" based on proximity to open public roads, size of private land parcels, and drainages. Each block during each time period was classified as either "Access" or "No-Access". Total area (km^2) and area of private land in each block was measured. Areas of open vegetation, open vegetation ≤20° slope, open vegetation ≤10° slope, and ≤2350 m elevation were measured in each block (Skovlin 1982). Areas were measured using an electronic planimeter on 1:62,000 USGS topographic maps.

Cedar Creek, Stands Basin, and Trestle (Fig. 3) were identified as No-Access blocks during both periods. Because recreational use other than hunting was minimal during the Hunt period, Sphinx Creek and Deckard Flats (Fig. 3) were considered No-Access blocks during the Hunt period, but not during the Spring period. Even though mostly private land, the Mol Heron block (Fig. 3) was considered an Access block during both periods except for a December 11, 1986 census which followed the general hunting season. During the Hunt period there was a significant amount of hunting via an outfitter, by landowner permission, and on public lands. During the Spring period, ranching activities and county road traffic were considered significant. Elk harvest data are taken from Montana Department of Fish, Wildlife and Parks (MDFWP) annual reports (MDFWP 1984, 1985, 1986, 1987).

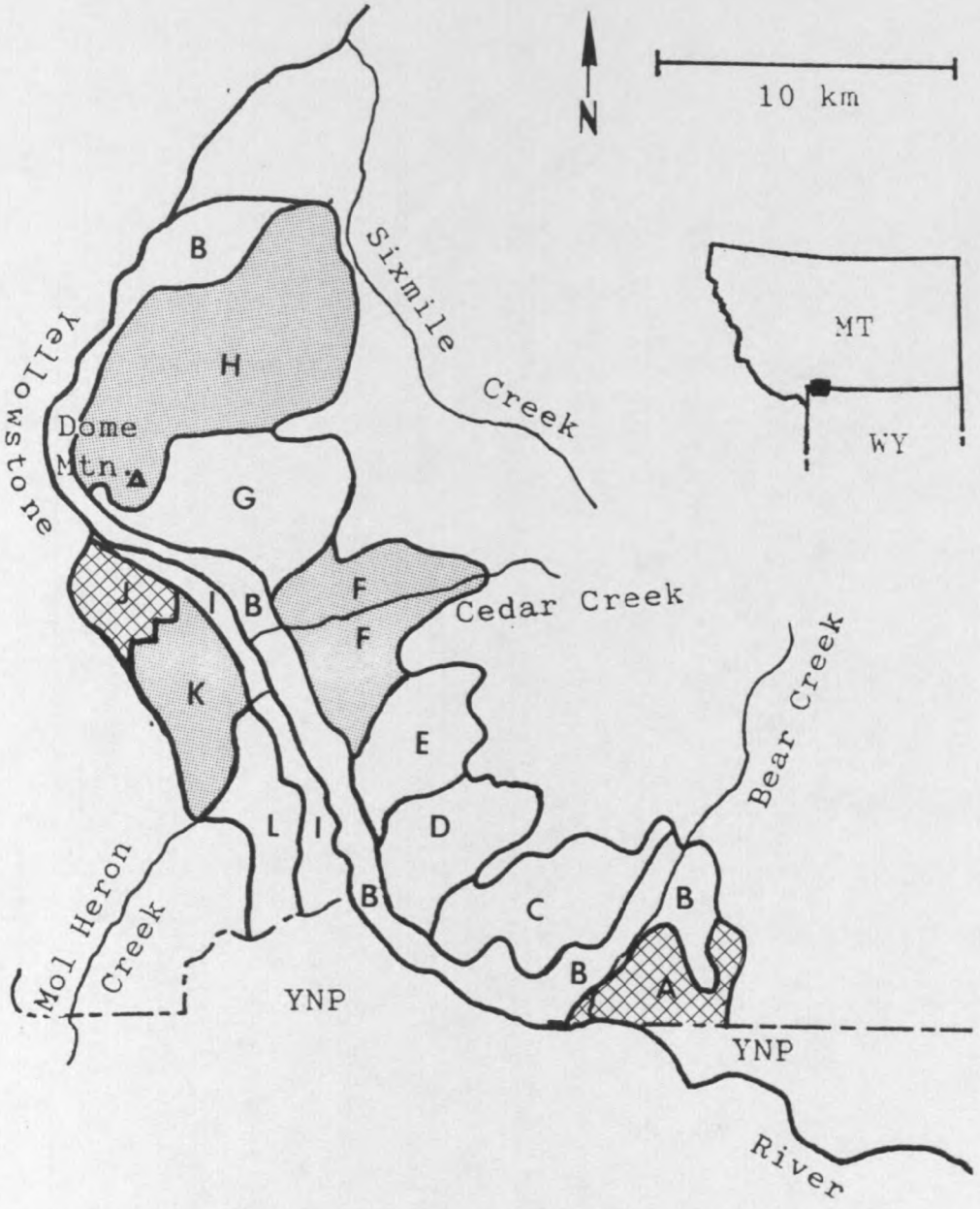

Figure 3. Study area land blocks used in analysis of elk distribution. A) Deckard Flats, B) East Road, C) Eagle Creek, D) Little Trail Creek, E) Bassett Creek, F) Cedar Creek, G) Slip and Slide Creek, H) Stand's Basin, I) West Road, J) Sphinx Creek, K) Trestle, L) Mol Heron. Stippled blocks were No-Access areas during Hunting and Spring periods. Cross-hatched blocks were No-Access areas during the Hunting period but not during the Spring period.

Two data sets, census flights and marked elk relocations, were used in analyzing elk distribution. The MSUSTAT (Version 4.12, 1988, developed by Richard E. Lund, Montana State University, Bozeman, Montana 59717) computer program was used in data analysis unless otherwise specified. The distribution of elk observed during census flights was compared to that expected if the same number of elk were uniformly distributed on the winter range using Chi square tests following Neu et al. (1974) and Beyers et al. (1984). Elk distribution within 10 days of a hunting season closure was assumed to reflect the effects of hunting.

The distribution of radio-marked elk was analyzed relative to the estimated percent of days elk spent in Access blocks [(days in Access blocks ÷ total days) X 100]. The natural logarithm (ln) of the percent days was compared among years, herd segments (Resident, Migratory, and West River), and periods (Hunt and Spring) using a 3-way analysis of variance (SAS 198) in consultation with Montana State University Statistical Services. The natural logarithm transformation was used to more closely approximate a normal distribution (Sokal and Rohlf 1981). The analysis assumes that variances of the compared populations are equal and that observations are independent.

Movements of radio-marked elk were analyzed with respect to herd segments, land access blocks, and 2 parts of the Spring period by determining whether or not an animal had moved during the interval between relocations. A movement was defined as a change of drainages or ≥5 km. To avoid sampling bias, only relocations where ≥80% of all marked elk were located within ±3 days of each other and subsequent locations were separated by >10 days were used. The spring period was divided into 2 parts, pre- and post-April 15. This date approximates the beginning of intense antler hunting/spring recreation. Differences in the number of movements versus no-movements made by elk relative to herd segment, land block, and early versus late in the Spring period were evaluated by Chi square tests. The average vector (distance and direction) of movements made by Migratory elk were plotted to determine if elk were moving toward the Park.

The estimated dates on which marked elk left their terminal winter range were regressed on the distances they travelled to spring and summer ranges, respectively. Differences among years for the average date elk left terminal winter range were compared with the departures from the normal blooming dates of honeysuckle (*Lonicera tartarica*) and lilac (*Syringa vulgaris*) (Caprio 1984, 1985, 1986, 1987).

Classifications

Winter age and sex classifications on the entire Northern range (both inside and outside YNP) were done before the late hunt started and/or before elk moved to areas open to hunting. Other age/sex classifications were made opportunistically through winter and spring. During March and April of 1985 and 1986, male elk were catagorized as antlered or antlers shed.

Diet Composition and Pregnancy

Reticulo-rumen content samples were collected from the discarded vicera of hunter-killed elk during the 1984-85 late hunt. Percent by volume and occurrence of contents were determined following Greer et al. (1970). At most sites the sex, age (calf or adult, based on size of of organs), and pregnancy status (if adult female) of the slain animal was recorded. Estimated conception dates of fetuses were determined according to Morrison et al. (1959).

Winter-killed Elk Carcass Survey

The distribution of winter-killed elk carcasses was sampled on 13 transects along the 2 major elk migration routes leading out of YNP. Carcass locations were plotted on aerial photo overlays. Sex, age at time of death, missing antlers and/or canine teeth, and any sign of hunter-inflicted wounds were recorded. Physical condition

at time of death was determined for some elk by the color and consistency of femur marrow (Greer 1968). Carcasses were marked with spray paint to avoid double counting.

Transect routes followed creeks and only carcasses that could be seen while walking along the creek bottoms were counted. Other carcasses were recorded but not included in analysis comparing carcass densities between transects. All carcasses were used in demographic analysis of the the carcass population.

Because of known herd segment movements (Craighead et al. 1972, this study), only transects north and east of the Yellowstone River were used for comparing carcass densities along a migration route. Also, since carcass densities were greatest in the lower portions of transects, only the lower 3.25 km of the longer transects were used in comparisons.

The 1 km portion of a transect with the most carcasses and other 1 km portions with ≥10 carcasses were defined as high carcass density (HCD) sites. The topography of HCD sites was evaluated by estimating the degree slope of the drainage sides and the stream gradient from a 1:24,000 USGS topographic map. The average drainage side slope was the mean of 11 slope measurements on 1 side of the stream taken at 100m intervals. One slope measurement was the amount of vertical rise in 150 m horizontal and perpendicular to the drainage axis.

RESULTS

Elk Capture, Marking, and Mortality

Thirty-two elk were captured and marked: 12 in 1984, 10 in 1985, and 10 in 1986 (Appendix A Table 17). In 1984, all elk were caught in Stands Basin (Fig 2). In 1985 and 1986, 16 were caught near the YNP boundary, 2 in Slip and Slide Creek, and 2 near Sphinx Creek (Fig. 2). Twelve elk were Migratory, 4 Resident, 14 West River, and 1 died before a determination could be made. Elk 76301 (3-5 yr. old female) was a Resident the year following her marking in 1984, but in the spring of 1985 became and remained a Migratory animal. In the fall of 1985 Migratory elk 88402 (2 yr. old Female) emigrated from the population to the Sunlight herd in Wyoming (see Houston 1982 for herd delineations).

The average age of 12 elk darted from a helicopter was 5.6 years while 20 caught in Clover traps averaged 2.7 years old. Helicopter darting was purposely biased against calves. Excluding 4 calves captured, the average age of Clover-trapped elk was 3.7 years.

A total of 1271 relocations of marked elk was obtained including 687 aerial and 474 ground radio relocations and 110 visual observations. Thirty elk provided seasonal

range and movement information, representing 46 to 63 elk-years per season over the course of the study.

Fourteen known marked elk mortalities and 1 suspected mortality (cow 25901 may have lost her collar) occurred during 62 elk-years; 11(79%) of these were hunter harvests. One hunting mortality (3½ yr. old male 49201) occurred on Deckard Flats (Fig. 2) on 01 December 1985 during the general season. Since late season hunters were asked to avoid harvesting marked elk it is assumed estimates of hunting mortality are conservative.

Of 3 known and 1 suspected non-hunting mortalities, 2 were winter kills, 1 in early summer (3 yr. old male 19101 between June 30 and July 13, 1985), and 1 probably died in late summer (9-10 yr. old female 25901 between July 13 and 27, 1985). The suspected late summer death of cow 25901 was preceeded by her calving on the unusually late date of June 30th. Cause of death for animals dying in summer was not determined.

Annual total mortality rates based on deaths/elk-year for Migratory, Resident, and West River elk were 30, 9, and 21%, respectively (Table 1). Hunting mortality for Migratory and West River elk were similar (22 vs 18%, respectively) and each about twice the 9% for Resident elk. The non-hunting mortality rate was higher for Migratory (13%) than for West River animals (4%). There were no non-hunting mortalities of Resident elk.

Table 1. Number, causes, and annual rate of mortalities of marked elk from 3 herd segments of the northern Yellowstone herd 1984-1987.

Herd Segment	Number of		Mortalities/Rate(%)		
	Elk	Elk-years	Hunting	Non-hunting	Total
Migratory	12	23	5/22	3/13*	8/35
Resident	5	11	1/9	0/0	1/9
West River	13	28	5/18	1/4	6/21
Total	30	62	11/17	4/6	15/24

* This includes one suspected mortality.

The Winter Range

Elk winter range outside YNP as determined by relocations of marked elk encompassed approximately 284 km^2 (Fig. 3 and Table 2). Twenty-four percent of this, referred to as the East-Road and West-Road blocks (Table 2, Fig. 3), was considered unsuitable because of human use and roads, thus about 215 km^2 of winter range was available to elk. Hereafter, reference to winter range outside YNP is to these 215 km^2 unless otherwise specified.

Marked Elk Seasonal Ranges and Movement Routes

The distribution of marked elk seasonal range GAC's is shown in Appendix B, Figs. 11-16. Elk were consistent in their use of terminal winter and summer ranges. However, use of other seasonal ranges was variable and apparently dependent on factors other than previous use of an area.

Table 2. Total areas (km^2) and areas of variables measured on 12 blocks of the Northern range outside YNP. Numbers in parenthesis are percents.

Name	Total Area	Private Land	Open/ Forage	Open/ Forage ≤20° Slope	Open/ Forage ≤10° Slope	Open/ Forage ≤2316m
Deckard Flat	14.3(5)[a]	1.2(8)	10.0(70)	6.3(44)	2.5(17)	8.9(62)
East Road	55.9(20)	37.1(66)	53.1(95)	39.3(70)	30.5(55)	55.3(99)
Eagle	26.0(9)	0.9(4)	20.6(79)	11.8(45)	7.2(28)	20.0(77)
Little Trail	16.9(6)	1.8(11)	9.6(57)	2.8(17)	1.4(8)	8.4(50)
Bassett	13.4(5)	0.6(4)	5.8(43)	1.1(9)	0.3(2)	4.0(30)
Cedar	25.0(9)	14.2(55)	18.8(72)	11.9(46)	4.4(17)	25.0(96)
Slip & Slide	29.2(10)	2.8(10)	20.2(69)	9.6(33)	2.9(10)	17.0(58)
Stands Basin	44.8(16)	39.4(88)	36.4(81)	16.6(37)	7.3(16)	40.6(91)
West Road	12.4(4)	4.4(36)	12.4(100)	9.3(75)	9.3(75)	12.4(100)
Sphinx	10.0(4)	0(0)	8.2(82)	3.3(33)	0.9(9)	10.0(100)
Trestle	17.4(6)	10.7(61)	16.0(92)	8.5(49)	3.4(20)	17.4(100)
Mol Heron	17.6(6)	13.8(78)	10.4(59)	4.9(28)	2.0(12)	17.5(99)
TOTALS	283.9(100)	126.9(45)	221.5(78)	125.4(44)	72.1(25)	236.5(83)

[a] Percents in area column are the percent of the winter range outside YNP, percents in remaining columns is the percent of the area column.

Resident elk generally spent terminal winter and early spring seasons in Stand's Basin or Cedar Creek. However, elk 76301 and 11501 moved north of Sixmile Creek following their capture and marking on March 10, 1984. Elk 11501 returned by early April but 76301 remained until after 02 June. During calving, rut, and early winter seasons, elk also used the Slip and Slide drainage. Resident animals summered in and around the head of Cedar Creek. Fall and spring migration routes were often through the head of Slip and Slide Creek or along the Slip and Slide/Sixmile Creeks divide.

Elk of the West River herd segment made heavy early winter, terminal winter, and early spring use of the BLA. Gardners Hole was used to a lesser extent. The Mol Heron, Trestle, and Sphinx Creek blocks were important terminal winter range areas, as was the Little Trail Creek block after the Hunting period (Fig. 3). These elk generally calved and rutted in Gardners Hole and summered in the surrounding mountains. Some elk used the portion of the BLA area east of Mammoth during the calving and rut seasons. In 1986, elk 79002 had a calf outside the Park just north of Mol Heron Creek (Fig. 2).

Early winter ranges of Migratory elk were often close to rutting ranges. Following use of these ranges, these animals typically made rapid, relatively long movements to terminal winter range. Migratory elk terminal winter

ranges were mostly in the Cedar Creek and Stands Basin areas but some elk moved to the Slip and Slide drainage after the late hunt (Fig 2). The Deckard Flats area was terminal winter range of 2 marked elk during 3 elk-years (Fig. 2). Early winter and early spring ranges of Migratory animals straddled the Park boundary along migration routes. Most calving ranges for adult (≥3 yrs. old) cows were located in YNP along the Yellowstone and Lamar Rivers, although 1 elk remained in Cedar Creek for 1 year and another was found east of Yellowstone Lake. Bulls and immature cows showed similar affinities. Summer ranges were at higher elevations along the Yellowstone and Lamar Rivers. Three elk summered east and south of Yellowstone Lake. Rut ranges included areas on the lower portions of summer range, the upper portions of winter range, and places in between.

Average estimated seasonal range sizes were similar among the 3 herd segments except that early winter and summer ranges of Migratory elk were larger than those of Resident and West River elk (Fig. 4). Comparisons of the average standard diameters of seasonal ranges among the 3 herd segments were similar to comparisons of range sizes except that the summer ranges of the three groups were similar.

Average distances between seasonal ranges for elk of the three herd segments varied from 1 km between terminal